

# **Feasibility Study of Semi-Automatic Pipe Handling System and Fabrication Facility**

U.S. Department of Commerce  
Maritime Administration

in cooperation with  
Avondale Shipyards, Incorporated  
New Orleans, Louisiana

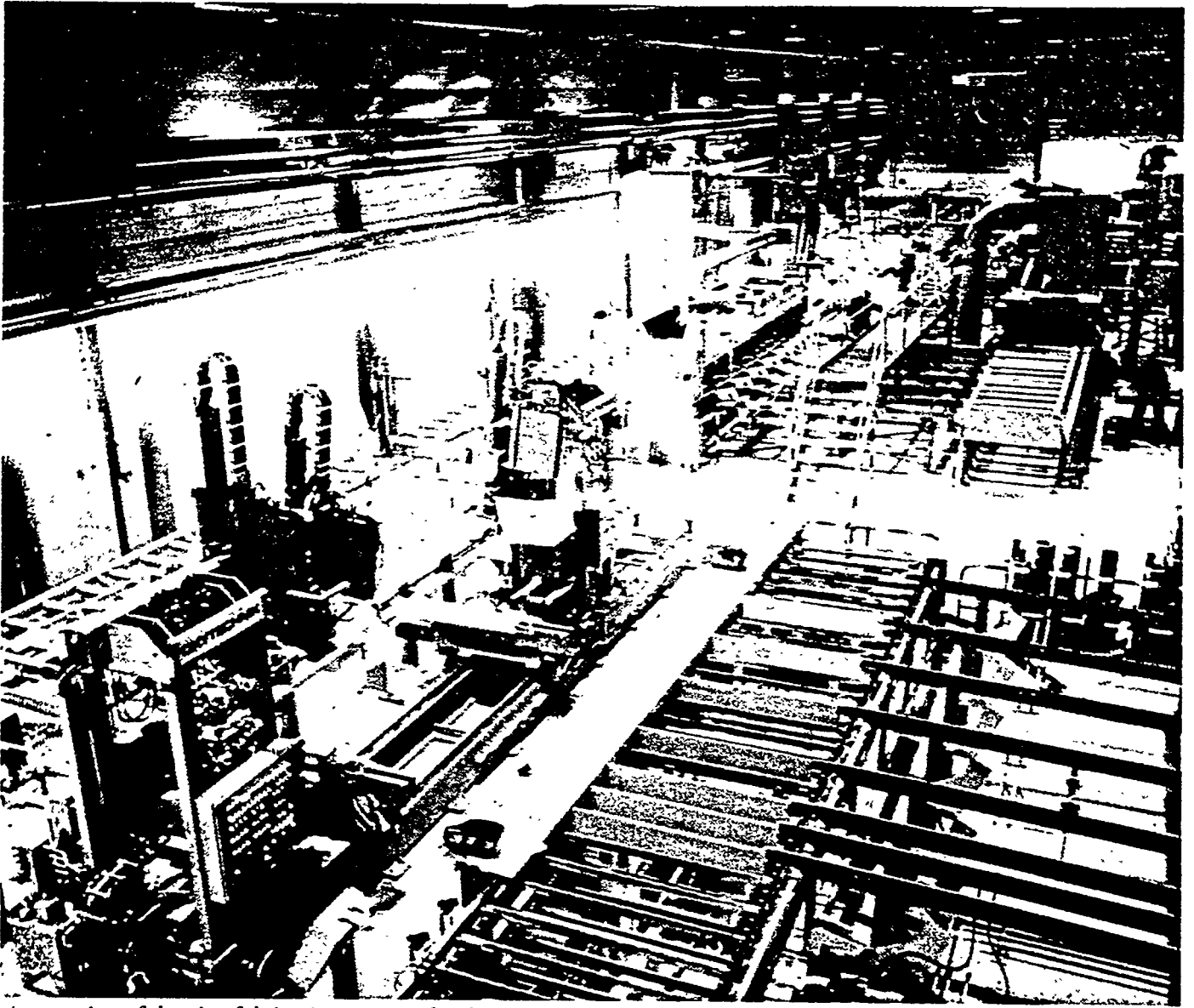
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## Executive Summary



*Automation of the pipe fabrication process for the shipbuilding industry.*

## Executive Summary

The primary objective of this study is to design a cost effective and semi-automatic method of fabricating pipe which will reduce the labor, material handling, storage space and required fabrication area.

Such a facility for the shipbuilding industry must be designed to handle 1½ inch through 24 inch diameter pipe and all ASTM Class and MIL-SPECS, and Schedules and alloys of pipe used in shipboard systems. The facility must be versatile and equipped to handle repair jobs and specialty items, as well as new vessel piping systems.

Our technical approach to this project fulfilled the stated objectives of the National Shipbuilding Research Program as established under the Merchant Marine Act of 1970. We have determined that a functional semi-automated Pipe Shop is feasible.

The following functions represent a pipe fabrication system which can be implemented along with certified procedures where necessary, either in part or as an entire system at any major shipyard.

1. A systematic rack storage and locator system for all types of pipe, in sizes from 1½ inch through 24 inch must be established. The storage racks must provide for loading, selecting and off-loading onto a transfer system automatically.
2. A sorting and automatic feed system must be installed at the pipe storage rack so that an operator can automatically select pipe from the rack, load it onto a conveying system and convey it to the work station.
3. The automatic conveying system, for movement of pipe from one work station to another, must be equipped with an automatic unloading device at each station, and a reserve area to hold pipe for each machine.
4. A measuring system must be installed to automatically measure pipe for cutting to length, locating holes and other layout requirements.
5. A system must be furnished to mark each component of the assembly with the specific part number as identified on the production drawings.
6. Cutting and end preparation machines must be provided. This function is extremely important since, in order to obtain good welding results, the use of machine cutting is an absolute necessity. At this point, all scrap must be conveyed out of the shop area by means of conveyors or other handling equipment.
7. An automatic flange fitting and welding device must be installed and have the capability of processing the pipe alloy mix as well as selecting the flange, orienting it properly, tacking it and welding both inside and out.
8. Adequate numerically controlled bending equipment must be provided capable of two diameter bending for up to Schedule 80 pipe 10 inches in diameter. Adequate bending facilities for larger pipe will depend on the number of ship systems for which larger pipe is required. It can be either hot bending or vibratory bending. An important function of this bending equipment, in addition to the two diameter bending for pipe up to 10 inch diameter, is the capability of being automatically fed and bent with flanges installed on both ends.
9. Various types of welding equipment must be selected which will be required to process the mix of pipe through the system. Rolling devices must be provided for the welding of straight pipe, and these should incorporate automatic loading and unloading mechanisms as well. The development of semi-automatic welding devices for sub-assembly areas is desirable, along with certified welding procedures.

10. Assembly areas must be equipped with manipulator fixtures designed so that assembly of pipe sections can be processed in an effective manner. Manipulators are to be fitted with semi-automatic loading and unloading devices, and must be capable of positioning the main body of pipe into position so that fitting and welding can be accomplished. The welding devices should be selected and developed concurrently with the manipulator fixtures for this function.
11. The configuration and quantity of X-ray booths and equipment required to support the maximum work load of this work station and provide handling equipment required for loading, manipulating and unloading the X-ray booths must be determined.
12. A semi-automatic internal and external blasting and coating system for pipe must be provided. A bypass would be included so that all full length pipe which does not require further processing would be channeled directly to the assembly area.
13. A specialty area for the fabrication of the inevitable "exception" must be designated. Machines, tools and handling equipment must be selected for processing specialty items of a configuration and volume not suitable for automatic and semi-automatic processing. This specialty area would be situated so that it would be accessible to the automatic conveying system. In general, work in this area would be accomplished by hand.
14. A final product storage system must be provided where the fabricated pipe and specialty items can be palletized and stored in a racking system, in usage order, until required. A locator system, to be used for accountability and retrieval, should control the storage function.
15. Transportation and handling equipment must be provided for selection, load-out and delivery of fabricated pipe to the installation site.
16. The computer software package must be developed to support this fabrication shop. Our investigation has revealed that all man-hour savings to be experienced by an automated system can be completely offset by a major increase in the engineering staff necessary to provide the drawing and other data in a timely manner. Therefore, a computer software package must be developed to operate this system and have the capability of preparing pipe detail drawings. As these drawings are being prepared, the program should select required information from data banks which would allow the concurrent preparations of bills of material, shop production schedules, material flow schedules, cutting lists, assembly marking and bending data, machine loading schedules and final disposition and delivery schedules.

The use of a mini-computer, supported by a primary computer, which could utilize a digitizer or some other method to design, update and revise the various parts of the system is envisioned.

The software package must be in the form best suited to the specific facility and working methods of the particular system, such as the order card of numerically controlled equipment, tape for tape controlled equipment and numerical list for other equipment and manual operation.

The cost to implement a system as described would require a capital investment of two to five million dollars dependent upon the existing shop facilities and the size, type and volume of the pipe to be processed.

With an investment of this magnitude, management can expect at least two things: (1) a return on their investment of approximately 35.4 percent per year depending on the facility; and (2) an extremely efficient pipe fabrication shop capable of meeting required production schedules. The system contemplated is designed to produce 150 pipe spools per day, with corresponding limited reduction of skilled shop manpower.

Fabrication cost of ship piping systems is roughly equal to one fourth of the total hull cost of a ship. For a 176,000 DWT tanker, this amounts to approximately 200,000 manhours. The study revealed that through automation a percentage of the required man-hours can be reduced in the following functions: Handling 68 percent; Fitting 55 percent; Welding 35 percent; Cleaning 79 percent and Coating 86 percent. These percentages are based on LASH vessel construction since all basic data is applicable to this series of ships. An overall percentage reduction in fabrication man-hours equates to approximately 39.8 percent per shipset.

## Foreword

## Foreword

Approximately two years ago, Avondale Shipyards, Incorporated submitted a proposal to the United States Maritime Administration covering the development of a semi-automatic pipe fabricating facility. This proposal was accepted and, since that time, we have been conducting an in-depth study of the subject. This study has been conducted at Avondale Shipyards' main Pipe Shop, and utilizes manual fitting, welding and burning as a data base, along with the original shop layout and flow diagram. Originally, Avondale Shipyards had a production capacity of 50 to 55 spool pieces per day with a complement of 76 people in this department and 8 people for surface preparation and coating. Basic changes which have been accomplished during this study such as wirefeed welding in lieu of stick welding, provision of a cutting station, installation of contour cutting machines and utilization of a limited amount of turning and manipulation equipment have increased our production to 60 or 65 spool pieces per day.

The following paragraphs summarize the state of the art of automated pipe fabrication systems:

There are several equipment manufacturers in the world today who have developed, and are marketing, automated pipe fabrication equipment for the shipbuilding and pipe fabrication industries.

Japan has two major manufacturers. The Ishikawajima-Harima Heavy Industries Company, Limited, or IHL system is very efficient, but is limited as to pipe diameter and to the processing of steel pipe only. It provides storing, marking, flange fitting and welding, cutting, bending, loading and transferring capabilities.

The Mitsui Engineering and Shipbuilding Company has a system called MAPS, which is similar to the IHI system in that it is limited in pipe diameters and does not provide for alloy mix suitable to the shipbuilding industry. We feel, however, that Mitsui could provide a complete shop. They have done outstanding planning in the development of a complete pipe facility as envisioned by this study.

IHI and Mitsui, as well as Hitachi Shipbuilding Company, Limited, can provide software packages to support the required degree of automated hardware and material control. Mitsui's software package is very sophisticated and seems to provide more desirable features than any of the existing systems. It has the capabilities for the engineering requirements including preparation of detail drawings, as well as shop planning.

The Maritime Administration has awarded a feasibility contract to Newport News Shipbuilding and Drydock Company for the development of a software package which would provide engineering, including digitizing, in support of an automated design system. If completed in

sufficient time, Avondale Shipyards will consider integrating the Newport News system with other available software packages to form an integrated engineering/shop control program.

In Germany, Oxytechnik has the capability of providing complete automated systems with the exception of branch welding, sub-assembly type work and a software package necessary for engineering and control of equipment. This manufacturer has been extremely energetic in adaptations to meet the requirements of various types of pipe fabrication process.

Kockums Shipbuilding Company has developed an excellent program nicknamed "System Q" and "Steer Bear" for use with the Oxytechnik system for production scheduling, engineering and material control within their own pipe fabrication shops.

Mecaval International, in France, has developed a pipe system, but it is limited to cutting, flange welding and numerically controlled bending and conveying equipment. St. Nazaire Shipyards has developed an outstanding fitting and welding system in support of the Mecaval system.

In Sweden, the ESAB systems have been limited to flange welding machines and manipulators. However, ESAB has developed exceptional welding equipment in the past, and is presently studying the feasibility of utilizing their robot in pipe welding. Preliminary data on this equipment indicates feasibility.

The Rauma Repola Shipyard in Finland has an Oxytechnik automated pipe facility which was the most complete and updated facility seen. All of this automated equipment is push button controlled. Their facility has a 100 spool per day production capability manned with 30 people. The management of Rauma Repola Shipyards indicated a better than 30 percent saving through automation.

In the United States, some welding technology has been developed, along with manipulators and turning devices.

Many companies in the United States have been visited, and a few in Europe, who are involved in processing pipe for chemical plants, oil refineries and pipe fabricating companies. In general, all pipe production we have witnessed is as inadequate, or backward, as it is in the ship building industry. . . with some noteworthy exceptions.

It has been determined that there is not a single totally automatic, or semi-automatic, pipe fabricating system available in the world today. However, most of the machines required for such systems are available in Europe, Japan and the United States.

It must be noted that the United States Department of Commerce Maritime Administration, in cooperation with Bath Iron Works Corporation, recently released a document entitled "Advanced Pipe Technology." This project is essentially a study of the mechanics of utilizing raw materials, equipment and human resources to produce finished ship piping systems, and covered state-of-the-art methods related to Piping Designed/Engineering, Piping Fabrication and Piping Assembly/Installation. Rather than duplicate the applicable data, we recommend the advanced Pipe Technology Study as a source for the detailed state-of-the-art.



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## Section I

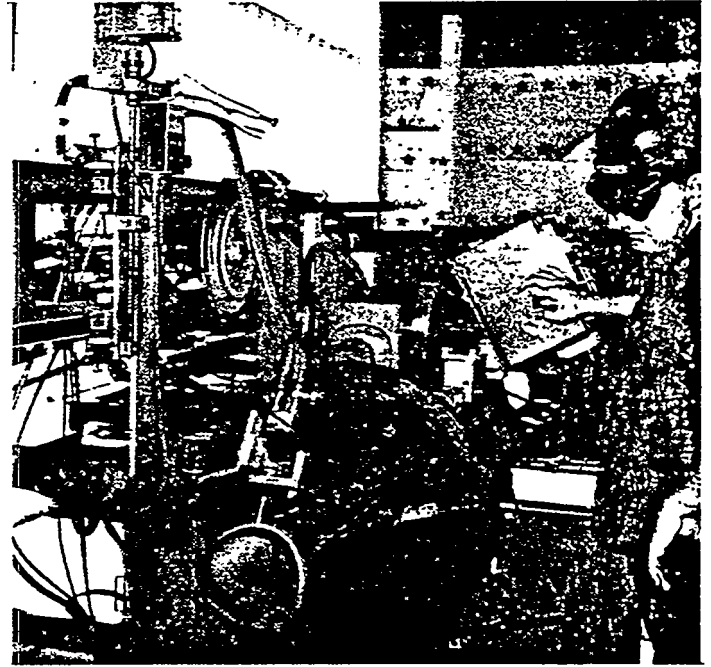
## **Section I**

Objectives and Research Conclusions  
Index

- A. Technical Approach Project
- B. General Procedures
- C. Objectives and Conclusions
- D. Anticipated Benefits
- E. On-site Facility Surveys



*Manual contour burning process.*



*Semi-automatic contour burning process.*

#### A. Technical Approach Project

The magnitude of this project made it necessary to subdivide the project into sixteen sub-projects functionally oriented. During the feasibility study, any one of the sixteen sub-projects could be developed independently of the other in respect to function, equipment, design or selection. Attention was given to sub-project interface to assure total project integration.

##### 1. Technical Approach

- a. Preliminary facility layout showing work stations, machine and equipment location, and conveying system routing was developed.
- b. Flow process charts showing flow through the facility, detailing the process through each work station, were established.
- c. Preliminary machine concept drawings were developed.
- d. Preliminary purchase equipment and machine listing were established.
- e. Existing equipment utilization listing is available.
- f. Preliminary equipment and machine installation phasing plan is available.
- g. Interface with the Ship Producibility Program was maintained.
- h. Semi-working scale model of the proposed facility is available.
- i. Cost estimates for implementing the proposal are available.

- j. This document represents the Phase I completion report prepared and forwarded to MARAD and the Ships Production Committee for review and comments.
- k. Layout, flow charts, time studies, flow process of existing system are included and have been used to compare the existing system to the proposed system.

#### B. General Procedure

Each of the sixteen sub-projects was developed through the following standard operating procedures.

##### 1. Determine the Present State-of-the-Art

We determined the state-of-the-art by site interviews with knowledgeable individuals in other shipyards and industries both foreign and domestic. Further, we conducted a search of literature and corresponded with selected technical societies.

##### 2. Identify Potential Participants

Through inquiry among the various interested shipbuilders, other industries and technical society members, we developed a list of potential participants. We screened these for significant prior experiences in conducting a disciplined R & D effort oriented toward specific objectives. Further, we screened them for their potential continued interest in the shipbuilding industry.

##### 3. Establish Priorities

The priorities for this project were based on the economic benefits of each area proposed.

##### 4. Solicit Various Vendors, Manufacturing and Consulting Firms for Proposals

A request for proposals was issued to various vendors, manufacturers and consulting firms. The response to our inquiries has been tabulated in various groupings, and a determination was made as to those qualified to participate.

##### 5. Evaluate Proposals

The evaluation of the proposals received was based on judging each against our previously established criteria.

Consideration was given to cost and the estimated benefits.

#### 6. Negotiate Subcontracts

After the proposals were evaluated, we entered into definite contracts with selected sources as appropriate with prior concurrence of the contracting officer.

#### 7. Develop and Demonstrate Prototypes

As commercially available prototypes were identified or developed, they were demonstrated under simulated and actual production conditions.

#### 8. Evaluate Results of the Project

The data collected during research and development work was evaluated.

#### 9. Submit Interim Reports

We submitted reports accompanied by informal oral progress reports. These were supplemented by formal progress reports.

#### 10. Evaluate Areas for Future Study

During the progress of this project, other areas which offered potential to the shipbuilding industry are being evaluated.

#### 11. Present Final Results and Reports

A summary of the data collected has been made and oral and written reports of the results presented.

### C. Objectives and Conclusions

#### 1. Semi-automatic Pipe Fabrication System Feasibility

- a. Process: Determine the design of a cost effective method of fabricating pipe assemblies for shipboard systems which will reduce the labor, material handling, flow through the system and space required for storage as well as fabrication area.
- b. Criteria The facility must be designed to handle 1¼ inch through 24 inch diameter pipe, all ASTM Classes and MIL-SPECS and Schedules, as well as copper nickle, stainless steel, etc. used in shipboard systems. The facility must be versatile and capable of handling new ship piping systems as well as repair jobs and specialty items.

The following items represent the fundamental requirements necessary for inclusion in a semi-automatic pipe fabrication system which can be installed individually or as a complete system with modification, implemented with certified procedures, where necessary, and fully utilized by any major shipyard as a production facility.

- Provide a systematic rack storage and locator system for storage of all ASTM Classes and MIL-SPECS and Schedule and copper nickel and stainless steel pipe stock.
- Provide an automatic feed pipe rack with push button select controls.
- Provide an automatic conveyance system to be used for moving pipe from one work station to another.
- Provide an automatic pipe measuring system.
- Provide an automatic marking system for part identification.
- Provide semi-automatic loaded cutting machine of a variety compatible with the alloy

mix of pipe going through the facility.

- Provide automatic flange fitting and welding devices capable of welding the alloy mix of pipe going through the facility.
  - Provide semi-automatic loaded bending machines capable of producing 1½ or 2 diameter bends . . . and provide a hot bending device and required heat source along with this for bending extra heavy wall pipe and large diameter pipe.
  - Provide the various types of welding machines to process the alloy mix of pipe going through the facility.
  - Provide manipulator fixtures integrated with various types of welding machines for processing sub-sub-assemblies, sub-assemblies and assemblies.
  - Provide X-ray facilities equipped with semi-automatic manipulator for positioning pipe assemblies during the time they are being processed.
  - Provide semi-automatic internal and external surface preparation systems for cleaning and pipe coating assemblies.
  - Provide machines, tooling and handling equipment for processing specialty items.
  - Provide racking system with automatic or semi-automatic locator system for temporary storage of palletized completed pipe assemblies.
  - Provide transportation and handling equipment for transporting palletized pipe assemblies from temporary storage to the installation site.
  - Provide a software package to support the fabrication facility.
- #### 2. Research Conclusions
- a. Operating under the general procedure, it was determined that there is not a semi-automatic pipe fabrication facility that meets the criteria as outlined. The semi-automatic pipe fabrication systems which exist today are considered to be partial systems limited as to pipe diameter and alloy mix. The existing systems are also limited as to the processes within the systems.
  - b. The existing semi-automatic pipe fabrication systems have one very important common denominator—they are very efficient, and they effect cost savings despite the limiting factors.
  - c. It was determined that most of the equipment, machines and devices required to meet the criteria are available in the world market today.

The task of modification of existing equipment, machines and devices remains, as well as the development of prototype machines that are necessary to fulfill the criteria as outlined.

#### 3. Feasibility

- a. It was determined that the criteria are sound.
- b. It was determined that the equipment, machines and devices that are available in the world market place can be purchased individually, used individually or modified and utilized by being integrated into a semi-auto-

matic pipe fabrication system.

- c. Considerable effort was directed toward studying the feasibility of machines required by the criteria but non-existent in the world today. The machines in this category have been proven feasible, however prototypes must be designed and the processes certified in order to categorize these items as production equipment.
- d. A semi-automatic pipe fabrication system as outlined in the criteria is feasible and can be installed on incremental base considering work station planning, or as a complete system, by any major shipyard. It is possible that smaller shipyards can automate on incremental base to the point that capital investments justify.

#### 4. Work Station and or Process Feasibility

The following will provide detailed information pertaining to available equipment, machines and devices and feasible equipment, machines and devices at the work station or process level.

##### a. Criteria-stormme of Raw Material

- Develop a systematic rack storage and locator system for storage of all pipe in sizes from 1½ inch to 24 inch diameter by wall thickness, ASTM or MIL-SPECS category, and alloy.
- Develop an automatic feed system for the pipe rack whereby an operator can select a specific pipe section from the rack, load the pipe onto the conveying system and convey the pipe section to the pre-selected work station, by-passing work stations not required. Selection, loading, conveying and work station to be push button controlled.

##### b. Research Conclusion:

Pipe storage racks meeting the criteria are available in Japan and Europe. Several foreign shipyards are presently using automatic feed racks to support their pipe fabrication facilities. Some domestic industry, such as chemical plants, oil refineries, etc. have recognized the need for systematic rack storage with automatic retrieval and have designed, fabricated and installed such racks. The storage racks seen in foreign and domestic plants varied in size, with capacities of from one week to six months' supply, with as many as 30 different sizes or alloys of pipe. The pipe racks currently installed at foreign shipyards were designed by the system supplier and made by the user. It was determined that no such racks are available for purchase as a stock item in the United States.

##### c. Feasibility

- Conclusions from our research prove that the storage of raw material as outlined in the criteria is feasible. Racks as described can be purchased as a production item or designed and built by the user to suit the user's needs.
- For inclusion in the proposed automatic pipe fabrication system, a prototype racking system must be designed. Conceptual drawings and specifications are included in the machine concept section of this document.

#### 5. Handling System

##### a. Criteria

It would be necessary to develop an automatic conveying system to be used for moving pipe from one work station to another. Each work station would have an automatic kick out and loading device, and would be equipped with controls to select the pieces of pipe with respect to size, wall thickness, alloy and length to be processed in sequence. Any pipe not requiring that process would by-pass the station and queue up for the next process according to the production drawing sequence.

##### b. Research Conclusions

- A conveyer of a design to transport straight pipe sections is available from domestic and foreign suppliers.
- Transporting bent or flanged pipe requires a special type of conveyer. Part of this type of conveyer can be purchased. The remainder must be designed to fit the facility.
- Loading and unloading kick outs and transfer sections are available both from domestic sources and from foreign suppliers. Some special loading and unloading devices would have to be designed to feed machines not previously automated.
- Automatic and/or push button controls are available for purchase as a stock item. The engineering requirements for proper sequencing and phasing, however, must be developed to suit the particular system being installed.
- It is possible to purchase the conveying equipment, loading and unloading kick outs and controls as a package. The user must determine, however, the type and quantity of conveyer loading and unloading, kick outs and controls required. This is a natural process during facility design and layout.

##### c. Feasibility

- Conclusions from our research prove that the handling system as outlined in the criteria is feasible.
- Part of the handling system can be purchased-the balance must be designed. Prototypes must be tested.
- Concept designs and specifications are included in the machine concept section of this document.

#### 6. Measuring System

##### a. Criteria

A system must be developed which can be used to automatically measure pipe for cutting to length, bending and other layout requirements.

##### b. Research Conclusions

- The capabilities of measuring and cutting to length are available and installed on all cutting machines seen at automatic pipe fabrication facilities.
- Measuring and locating hole cuts is a manual operation in facilities visited.
- Measuring and layout of bends is automatically accomplished when using N.C. bending machines. Standard bending machine

measuring is manual.

- Assembly areas utilized manual measuring.

c. Feasibility

- Automatic measuring systems can be purchased for cutting machines (cut to length) and can be built into cutting machines.
- It is feasible to locate the center of holes to be cut after the pipe piece is loaded into the automatic hole cutting machine. A prototype must be designed and tested.
- Other layout requirements can be accomplished automatically. Prototype devices must be designed and tested.

7. Marking (Component and Assembly Part Identification)

a. Criteria

Develop a system which can be employed to automatically mark each component sub-sub-assembly, sub-assembly and assembly with the specific part number called for on the production drawings. Deploy this system as an attachment to the cutting machine.

b. Research Conclusions

Component and assembly part identification marking is a manual operation in domestic and foreign shipyards. The method of die stamping was studied, but proved unsatisfactory. This method is not acceptable by regulatory agencies for it is a potential pipe failure point.

c. Feasibility

A prototype marking device must be designed and tested. Concept design and specifications are included in the machine concept section of this document.

8. Cutting and Edge Preparation

a. Criteria

- Select the various cutting processes economically required to process the alloy mix of pipe going through the system. The quantity of each type of cutting machine must be controlled by the diameter range and alloy range of the specific cutting machine. Particular attention should be given to cutting speeds and quality.
- Develop an automatic loading and unloading device for each cutting machine that is push button controlled. The usable piece of pipe will be conveyed to the next work station. The scrap will automatically be dispensed for removal.
- Design edge preparation into the cutting machine for end cuts, with the exception of plasma cutting. The bevel can be done during cutting; however, provisions must be developed for final edge preparation.
- Develop an edge preparation system for hole cuts.

b. Research Conclusions

- It was determined that the cutting process is the most critical process in the automated systems. The point at which the pipe is cut is usually a fit and weld joint done later on during the production process. Based on this

conclusion, it became necessary to break down the criteria into types of cuts and study processes for each type. This was accomplished and the research conclusions follow.

- For square cut 1½ inch to 20 inch diameter pipe, it is essential that square cuts be processed as a machine cut utilizing a saw or cutting tool. If a bevel is required, this must be accomplished by a machine tool device. Cutting saws are available through a domestic supplier. Beveling machines are also available as a production item. Machine tool cutting and automatic beveling are available as a production item, but this type of machine is a slow process and not recommended for high volume usage. Saws are recommended for high volume pipe cutting for pipe 1½ inch to 20 inches in diameter. Pipe over 20 inches in diameter should be plasma/gas cut due to the sizing of saw (disc) blades and economics.

● Contour End Cuts

Plasma/gas contour cutting machines are readily available through domestic or foreign suppliers. These contour cutting machines have the capability of cutting the desired contour and beveling simultaneously. Edge preparation is necessary and presently is accomplished manually.

● Hole Cuts

Boring machine cutting of holes is possible but not cost effective. The most cost effective production process is plasma/gas cutting, with hole edge preparation again accomplished manually. Some noteworthy development work is taking place in this area. There is a system manufactured by T/Drill which can produce the holes necessary for branch pipe work. Details on this device are covered in the Advanced Study section of this document.

c. Feasibility

- High speed cutting saws, plasma/gas contouring machines and plasma/gas hole cutting machines are available for purchase through domestic or foreign suppliers.
- Automatic beveling machines are available. A prototype machine, however, must be designed and tested to meet the criteria cost effectively.
- Concept design and specifications for cutting stations are included in the machine concept section of this document for inclusion in the proposed semi-automatic pipe fabrication system.

9. Automatic Flange Fitting and Welding

a. Criteria

Develop automatic flange fitting and welding device. Select and incorporate into the device the various welding processes required to process the alloy mix of pipe going through the system. The quantity of auto flange fitting and welding devices will depend upon the diameter range designed into the devices. Each device will have push button selectivity for



weld procedure, loading and unloading.

b. Research Conclusions

- Automatic flange fitting and welding machines are available from foreign suppliers only. The existing machines are limited to pipe size and alloy.
- The general opinion of domestic shipbuilders is that flanging is a small part of the work load. It was determined that, through automation, this segment of the work load would expand, reducing field fitting and welding.
- During the research in this area, it was determined that if a flange finish device is desired, such a device is available from foreign suppliers. Its use would be to clean the inside weld, dressing the weldment, and that it should be included with the work station.

c. Feasibility

- Conclusions from our research prove that automatic flange fitting and welding is feasible. The basic machine is available. A prototype machine fitted with an interchangeable welding system must be developed.
- A prototype flange fitting device must be designed to allow for the various types of flanges used in domestic shipyards.
- An automatic loading and unloading device must be modified to fit the feed conveyor and automatic flanging machine.
- The automatic flange finishing machine must be modified and fitted with loading and unloading mechanisms.
- Concept drawings and specifications are available in the machine concept section of this document.

10. Bending

a. Criteria

- Select and/or develop bending machines capable of producing 1½ and two diameter bends with or without flange.
- Develop automatic loading and unloading device-one for each bending machine.
- Select bending equipment for large diameter pipe.

b. Research Conclusions

- Flanges on N.C. bending machines for pipe range from 2 inch to 12 inch diameter are available from foreign suppliers. The domestic bending machine manufacturers indicated no interest in developing the capability of handling flanges on bending machines over 8 inch diameter.
- Loading and unloading devices for bending machines are available from foreign suppliers.
- The volume of large pipe requiring bending may not be sufficient for automation, however vibrator bending or high frequency bending machines are available from foreign suppliers.

c. Feasibility

- Bending machines meeting the criteria for pipe ranging from 2 inch to 12 inch diameter are feasible.

- Loading and unloading devices are available—however, prototypes must be designed for automation and conservation of space.
- Large pipe, as outlined in the proposed Pipe Shop layout, is a low volume work load—therefore, hot bending will suffice.
- Conceptual drawings are available in the machine concept section” of this document.

11. Welding

a. Criteria

Select the various types of welding machines required to process the alloy mix of pipe going through the system. Develop a rolling device for welding straight pipe, incorporating an automatic loading and unloading mechanism controlled by push button.

b. Research Conclusions

- Various types of welding machines are available from foreign and domestic suppliers. Substantial research in welding technology has taken place in Europe, Japan and the United States.
- It was necessary to detail the criteria during the progress of this study. The criteria were revised to automate welding through the use of manipulating the welding gun and/or manipulating the work piece.
- Butt welds can be accomplished successfully by rolling the work piece. The welding gun is fixed in this operation.
- Branch welding 90 degrees can be accomplished by manipulating the welding gun; the work piece is fixed.
- Branch welding 45 degrees, 60 degrees can be accomplished by manipulating the welding gun and the work piece.

c. Feasibility

- Semi-automatic welding of butt welds and branches 90 degree, 60 degree. 45 degree is feasible through manipulating the welding gun and/or the work piece.
- Additional information on this process is available in the Advanced Study section of this document.
- Conceptual design and specifications are available in the machine concept section of this document.
- Prototype machines must be designed and tested.

12. Assembly Area

a. Criteria

Develop manipulators and fixtures whereby sub-sub-assemblies, sub-assemblies and assemblies of pipe sections can be processed in the most cost effective way. The manipulator is to be fitted with semi-automatic loading and unloading devices, and of a design capable of positioning the main body pipe section so that fitting and welding of tee sections can be accomplished.

b. Research Conclusions

- The manipulators and fixtures outlined in the criteria were studied concurrently with the welding machines.

- Work piece manipulator rolling devices and fixtures are available from domestic and foreign suppliers. However, these devices must be fitted with loading and unloading mechanisms.
  - It must be noted that not one facility visited during the course of this study has made any effort to automate the assembly area.
- c. Feasibility
- In the area of branch welding, research shows feasibility with respect to manipulating main pipe for fitting and welding 45 degree, 60 degree branches.
  - After prototype welding equipment is designed and tested for 90 degree branch welding, 45 degree and 60 degree prototypes will follow.
13. X-ray Equipment
- a. Criteria
- Develop the configuration and quantity of X-ray booths and equipment required to support the maximum work load passing through the work station. Develop semi-automatic handling equipment required for loading, manipulating and unloading the X-ray booths.
- b. Research Conclusions
- Research disclosed that this basic X-ray equipment is available but requires modification for automation.
  - Prototype equipment must be designed and tested.
  - Loading and unloading devices are available and can be purchased on the domestic market. This equipment will need modification to suit the facility.
  - In the facilities visited during the course of this study, X-ray work stations were excluded from automation.
- c. Feasibility
- It was determined that an X-ray work station can be operated semi-automatically. A conceptual design is available with specifications in the machine concept section of this document.
14. Surface Preparation and Coating
- a. Criteria
- Cleaning-develop a semi-automatic internal and external surface preparation system for pipe before the fabrication process is complete.
  - Coating-develop a semi-automatic internal and external coating system for pipe before the fabrication process is complete.
- b. Research
- External pipe cleaning machines are available from both domestic and foreign suppliers. The machines studied varied in configuration. Some have the capability of processing four (4) twenty (20) foot long pipes at one time.
  - Internal pipe cleaning systems are also available.
  - Research pointed out that existing internal and external cleaning systems are treated as two separate work stations. The internal systems seen were not automated.
  - External pipe paint system are available. They are automated and positioned adjacent to or in the near proximity of the external blasting machines.
  - Internal coating is applied manually.
- c. Feasibility
- It was determined that the equipment necessary for external blasting is available. Through engineering modification, it is feasible to blast internal and external pipe sections automatically. A prototype machine for internal and external blasting. must be designed and tested.
  - Concept drawings and specifications are available in the machine concept section of this document.
  - The same situation exists with internal and external painting. Prototype equipment must be designed and tested for automating the cleaning process as well as the painting process.
15. Specialty Area
- a. Criteria
- Develop an area by selecting machines, tools and handling equipment for processing specialty items of a configuration and volume not suitable for automatic or semi-automatic processing. This specialty area would be part of the Pipe Shop, and its location should be accessible to the automatic conveying system. This would provide a cost effective utilization of auto cutting end preparation-bending, hole cutting, X-ray equipment, etc.
- b. Research Conclusions
- The equipment requirements for a specialty work area are available as production equipment.
  - The handling and manipulation of the work piece in this work station is presently accomplished manually.
- c. Feasibility
- It is feasible to locate this work station where, by prefabrication, sub-assemblies can be transported to this work station by the automatic conveying system.
  - The selection of special manipulators can improve efficiency in this area.
  - Prototype manipulators must be designed and tested.
16. Final Product Temporary Storage
- a. Criteria
- Develop a system whereby fabrication pipe and specialty items can be palletized and stored in a racking system in usage order until required for shipboard installation. Provide an automatic locator system to be used for accountability and retrieval.
- b. Research Conclusions
- Temporary storage areas have been seen at most of the yards visited during the process of this study. Most of the equipment required is available and can be purchased.

Extensive modifications, however, would be required.

c. Feasibility

- The problem with this area is that the storage system must be designed in the configuration necessary to work with the production criteria of the specific shipyard. For example, if a certain shipyard installs pipe in sections prior to hull erection, the temporary storage requirements are different from installing pipe systems after hull erection is completed.
- Final product temporary storage as outlined in the criteria is feasible. Prototype equipment must be designed and tested.

17. Transportation and Handling of Final Product to Installation Site

a. Criteria

Select and/or develop cost effective transportation and handling equipment for the selection, picking up, transporting and delivery of fabricated pipe and specialty items to the installation site.

b. Research Conclusions

- The equipment required to support this function is available for purchase.
- Selection must be done with consideration given to the design of the temporary storage system.

c. Feasibility

Based on research, it was determined that the transportation system is feasible.

18. Software

a. Criteria

Develop a software package to operate this system that would have the capability of preparing pipe detail drawings. As these drawings are being prepared, the program should select the concurrent preparation of bills of material, shop production schedules, material flow schedules, cutting lists, assembly marking and bending data, machine loading schedules and final disposition and delivery schedules. Several "stand alone" but integrated software packages, to suit the level of automation and types of equipment eventually selected, will probably be required. The implementation of the required software will require complete application capability which is available at most major ship yards.

b. Research Conclusions

- Software packages are available and can be purchased from foreign suppliers.
- The Maritime Administration has funded a feasibility contract to Newport News Shipbuilding and Drydock Company for the development of a software package which would provide engineering-including digitizing-in support of the automated design system.

c. Feasibility

- A software system meeting the criteria is feasible.
- A software system developed by Mitsui Engineering and Shipbuilding Company

Limited is included in Section III of this document to illustrate the scope and requirements.

D. Anticipated Benefits

The major benefits anticipated through the development of this project fall into the following area.

1. Excessive Handling
2. Fitting
3. Welding
4. Cleaning and Coating
5. Labor Expense
6. Process Flow Time

Using a LASH ship as a base, we estimate the percentage saving for each of the following items.

REDUCTION PER SHIPSET

1. Handling Man-hours 68 percent
2. Fitting Man-hours 55 percent
3. Welding Man-hours 35 percent
4. Cleaning Man-hours 79 percent
5. Coating Man-hours 86 percent

Using these percentages as a base, it is conceivable that Avondale could fabricate all ship piping systems for 45,000 man-hours compared to 75,000 man-hour cost. This is an overall reduction of approximately 39.8 percent per shipset.

E. On-Site Facility Surveys

1. On-site Surveys of Foreign Facilities

FACILITY	LOCATION
Bayer AG	Dormagen, West Germany
Chantiers De L'Atlantique	St. Nazaire, France
Chantiers Di Castellammare	Naples, Italy
Di Sabin	
Chantiere Di Monfalcone	Trieste, Italy
Chita Shipyard (IHI)	Nagoya, Japan
ESAB-HEBE Company	Hallsberg, Sweden
Howaldtswerke-Deutsche	Keil, West Germany
Werdt (HDW)	
Ishikawajima-Harima	Tokyo, Japan
Heavy Industries	
Italcantieri-Cantiere De	Geneva, Italy
Geneva-Sestri	
Kockums AB	Malmo, Sweden
Larikka Company (T-Drill	Vaasa, Finland
Company)	
Messer-Greishiem	Frankfurt, West Germany
Mitsui Chiba Yard	Chiba, Japan
Mitsui Engineering&	Tokyo, Japan
Shipbuilding Co.	
Heinrich J. P. Muhlham Co.	Bremen, West Germany
Nippon-Kokan	Nagoya, Japan
Oxytechnik	Frankfurt, West Germany
Rauma Repola Shipyard	Rauma, Finland
Wartsila Works	Ylvieska, Finland

2. On-site Surveys of Domestic Facilities

FACILITY	LOCATION
Babcox/Wilcox, Inc.	West Point, Mississippi
Bath Iron Works Corporation	Bath, Maine
Conrac Corporation, Tool	Westminister, California
Division	
Cypress Welding Equipment	Houston, Texas
co.	
E. L Dupont Company	Albany, Georgia
E. I. Dupont Company	Orange, Texas

Fairfield Machine Company	Columbiana, Ohio
Gaido-Lingle Company, Inc.	Houston, Texas
General Dynamics Corporation	Quincy, Massachusetts
Quincy Shipbuilding Div.	
Ingalls Shipbuilding	Pascagoula, Mississippi
Division of Litton Industries	
National Steel & Shipbuilding Co.	San Diego, California
Newport News Shipbuilding and Dry Dock	Newport News, Virginia
Porta Tools, Division of DND Corp.	Houston, Texas
Benjamin F. Shaw Co.	Laurens, South Carolina
Southeast Fabricators Co.	Baton Rouge, Louisiana
Southwest Fabricating & Welding Co.	Houston, Texas
W. K. Stamets Company	Columbiana, Ohio
Steffan Manufacturing Corp.	Salem, Ohio
Texas Pipe Bending Co.	Houston, Texas
Todd Shipbuilding Corp.	San Pedro, California

## Section 11

## **Section II**

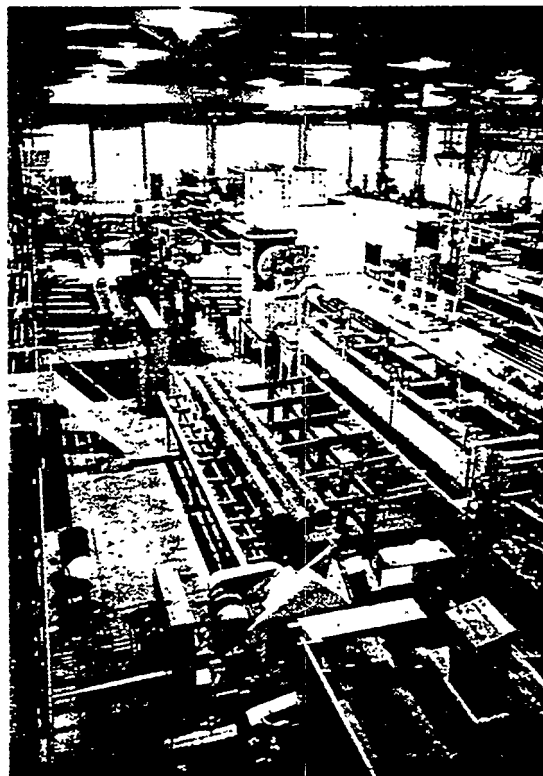
Proposed Semi-automatic Pipe Fabrication Facility

### **INDEX**

- A. General
- B. Basic and Principal Features
- C. General Condition
- D. Actual/Proposed Time Comparison
- E. Equipment Requirement
- F. Plan View of Pipe Fabrication Facility
- G. Isometric Layout of Pipe Fabrication Facility
- H. Illustration of Pipe Fabrication Process
- I. Production Flow and Production Rate of  
Pipe Fabrication Facility
- J. Specification of Equipment and Machines  
with Concept Drawings



*Manual pipe fabrication facility.*



*Semi-automatic pipe fabrication facility.*

## A. General

This section is dedicated to the conceptual design of the proposed semi-automatic pipe fabrication facility. Included are specifications and machine concept drawings which we believe are essential.

Avondale Shipyards' existing Pipe Shop was used as the base during the development planning required to produce the facility layout, fabrication sequence, production flow and production rate.

## B. Basic and Principal Features

1. The basic idea in studying and planning this proposed pipe processing system is as follows:
  - a. This system is to be an integrated processing line with automation.
  - b. In the planning of this new semi-automatic Pipe Shop, great emphasis was placed on the automation of welding and a handling system that does not use cranes.
  - c. Concerning the effects of automation, the aspects of not only saving man-hours but also standardizing fabrication methods, improving fabrication precision and achieving centralized control of scheduling and material handling should be considered.
2. The principal features of the equipment to be installed in the new semi-automatic Pipe Shop are as follows:
  - a. A Surface preparation system for raw material. The internal side of the pipe would be cleaned automatically in a closed cabinet by the use of a shot blasting lance. The external surface would be blasted using a blasting device located inside the closed cabinet.
  - b. An automatic marking, measuring and cutting system. Two kinds of cutting machines would be used depending on the diameter of the pipe. For pipes 1½ to 10 inches in diameter, machine cutting would be used. For pipes 12 to 24 inches, plasma or gas cutting would be applied with consideration given to the versatile use of the material. All of the work, from bringing in pipes to taking away scrap pipes, would be automated in accordance with the machine instruction system.
  - c. A flange fitting and welding system. Four kinds of automatic welding machines would be used depending on the size and types of flanges. For steel slip on type flanges of 2 to 10 inches in diameter, a push button flange fitting and welding machine would be used. For stainless steel and non-ferrous metal flanges of 2 to 10 inches in diameter, TIG welding. Butt flanges with consumable insert rings would be used to save the time required for exchanging filler wires depending on the flange material. For weld neck flanges on 2 to 10 inch pipe diameters, one side plasma arc welding with back shielding gas would be used to obtain high quality weld joints that will pass the stringent X-ray inspection. For steel flanges of 12 to 24 inch diameter, gas metal arc welding processes would be utilized. In these welding machines, positioning of welding torches before welding would be done manually if necessary—but,

during welding, it would be done automatically by arc voltage controls and sensing groove detectors.

- d. A bending system with suitable loading and unloading device.

Three types of cold benders coupled with automatic pipe loader and unloader would be used—4 inch, 8 inch and 12 inch flange on benders for pipe up to 4 inch, 8 inch and 12 inch diameter . . . each equipped with punch card machine instruction devices. For extra heavy wall pipe and large diameter pipe, a hot bending process would be used.

- e. An assembling and welding system. for elbow and branch pipe.

Fitting and welding of branch pipe to main pipe over 14 inches in diameter would be processed manually. A prototype 90 degree branch welding device has been developed proving the feasibility of semi-automatic welding of branch pipe to main body pipe. A production model of the 90 degree branch welder can be manufactured. For fitting of branch pipe to main pipe, a branch pipe positioner would be loaded manually. Branch pipe from storage would be set to main pipe in the suitable position. A series of this movement would be controlled by push button operation. Included with the 90 degree branch welder is a hole cutting device which is push button controlled and semi-automatic, with quick select burning systems. Also designed into this equipment are 40 degree and 60 degree burning and welding of branches 12 to 24 inches in diameter with semi-automatic push button control for load manipulating, burning and welding. Concept drawings are available. For fitting of elbow to straight pipe, an elbow positioner and welding manipulator have been designed. A series of the movement from picking up the elbow in elbow storage to fitting the elbow in a suitable position would be semi-automatically controlled by push button operation. Welding of one end butt joint of the elbow would be semi-automatically carried out with pipe rotation.

- f. Various types of welding positioners and manipulators.

The following types of welding positioners and manipulators are designed to realize easy welding and to improve the efficiency and quality of the welding work.

- One set of GMA flange welding machines for short pieces less than 36 inches in length.
  - Universal welding positioner with GMA semi-automatic welder.
  - Pipe welding elbow fitting devices for pipes 2 to 30 inches in diameter.
  - Pipe rotation and welding manipulators for butt welding of pipe.
- g. X-ray facilities. Two sets of X-ray facilities are provided. One is for 2 to 10 inch pipe, and the other for 12 to 24 inch pipe. The X-ray generator is movable,



while the inspected pipe would be fixed on the pipe carrier. The X-ray generator can be easily set by hand with the assistance of a hand type manipulator.

h. Handling system.

In order to save man-hours and secure work safety, the plan is to use cranes as little as possible. For this purpose, the machines would be arranged in the pipe processing order with conveyers provided in the shop for handling the pipe. These conveyers would operate at safe speeds automatically, stopping at the designated work stations for removing pipe from the conveyer by instructions from cards or the select switch. The following devices would be provided to limit the use of cranes as much as possible:

Z Automatic pipe loaders for benders.

- Pipe unloaders for removing bent pipe from benders.
- Elbow positioners for fitting elbows to pipe.
- Branch pipe positioners for fitting branch pipe to main pipe.
- Motorized dollies for transporting complete pipe assemblies.

C. General Condition

This system shall perform under the following conditions.

1. Pipe

Diameter: 1½ through 24 inches  
 Length: Maximum single random  
 Material: Carbon Steel ASTM A53  
               Carbon Steel ASTM A106  
               Carbon Steel ASTM A135  
               Alloy Steel ASTM A335  
               Stainless Steel ASTM A312  
               Copper ASTM B42  
               Copper Nickel ASTM B466 & MIL-T-16420

Wall Thickness: Schedule 40 (STD), Schedule 80 (XS)

2. Flanges

Diameter: 1½ through 24 inches  
 Type Slip on welding steel pipe flanges  
       ANSI B16.5 150 LB, 300 LB, 600 LB and 900 LB.  
       Socket welding steel pipe flanges  
       ANSI B 16.5 600 LB, 900 LB and 1,500 LB.  
       Butt welding steel pipe flanges  
       ANSI B16.5 600 LB, 900 LB and 1,500 LB.  
       Slip on brazing copper pipe flanges  
       ANSI B16.5 150 LB and 300 LB.  
       Bronze Flanges  
       MIL-F-20042  
       Steel Flanges  
       MIL-F-20670

3. Daily Production Rate

Material	Steel	Non-ferrous	Pcs./Day
Size	Pipe	Metal Pipe	Total
1½ to 10"	66 pcs.	54 pcs.	120 pcs.
12 to 24"	15 pcs.	15 pcs.	30 pcs.
TOTAL			150 pcs.

Figures are estimated. For details, refer to "production flow and production rate." Working hours per day-8 hours.

4. Number of Workers

The number of workers needed to operate a semi-automatic pipe fabrication shop is estimated as follows.

Section	Number of Workers
Fabrication:	
Machine Operation	12
Welding	10
Fitting	10
Others (including supervision)	7
Material Preparation	3
Handling and Transporting in the Shop	3
Sorting and Palletizing	3
TOTAL	48 men

The above figure is estimated considering the fact that the shop is operated by trained and qualified workers.

D. Actual/Proposed Time Comparison

The following matrix compares nine functions. The existing operation was time studied at Avondale Shipyards' Pipe Shop.

The proposed operation is an actual cycle time utilizing automation to perform the same tasks. It must be noted that this comparison was made at two different places-therefore, it is not a single facility study. The study points out, however, the tremendous savings which can be attained by automating pipe fabrication facilities. The time measured was that required to load the machine, process the work piece, unload the machine. All other operations were omitted.

	Proposed	Existing
1. Pipe Storage Rack		
Cycle Time	1.5 Min.	10 Min.
Input Data		
a. Pipe Diameter		
b. Pipe Thickness		
2. Auto Punching		
Cycle Time	2 Min.	5 Min.
Input Data		
Punching Position		
Punching Letters		
3. Auto Marking		
Cycle Time	2 Min.	10 Min.
Input Data		
Pipe Diameter		
Marking Positions		
4. Auto Cutting		
Cycle Time	2 Min.	10 Min.
Input Data		
Pipe Diameter		
Cutting Position		
Cutting Shapes		
Sorting Destinations		
5. Auto Flange Fitting/Weld		
Cycle Time (Including Weld)	5 Min.	25 Min.
Input Data		
Position of Flange Holes		
Welding space		

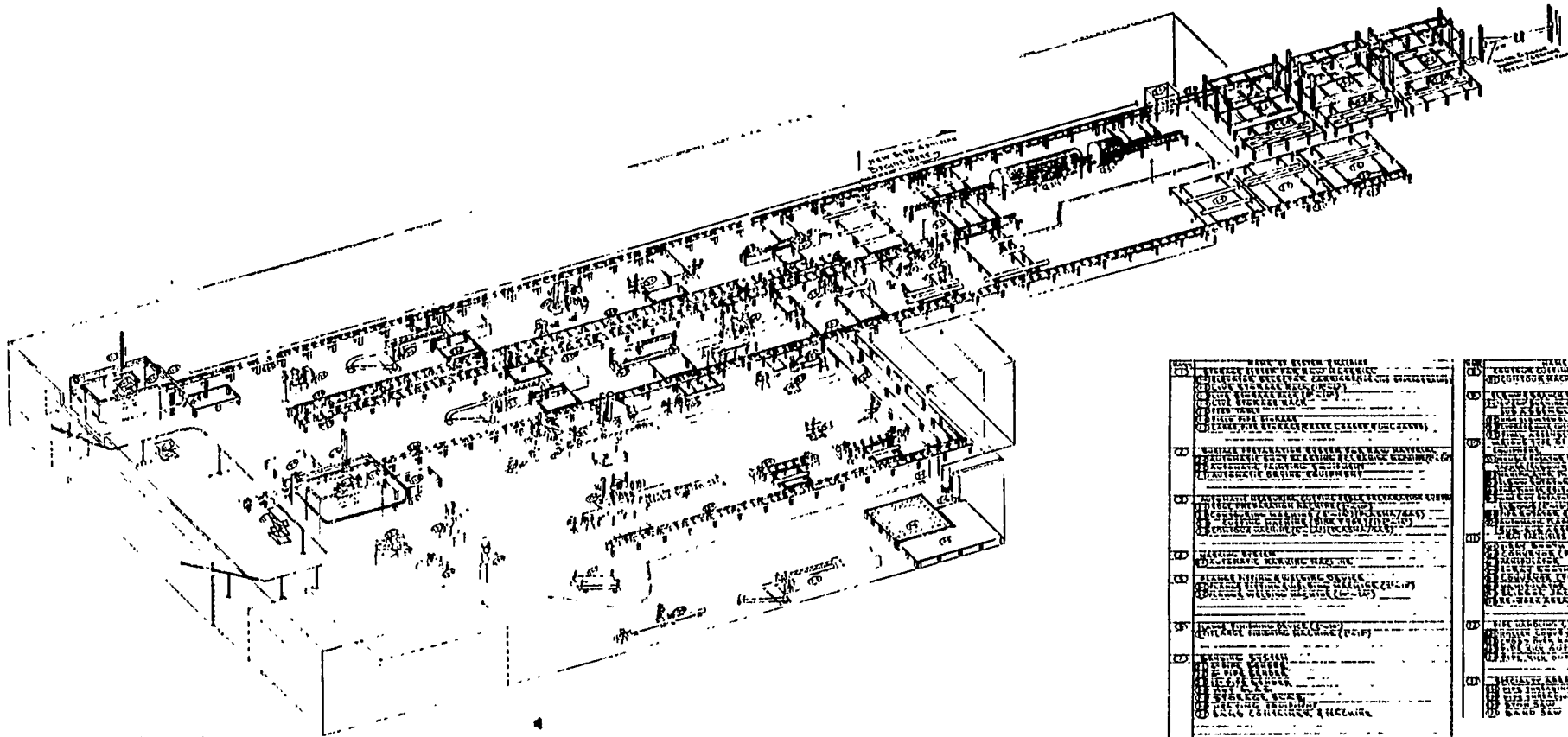
	Tack Welding Conditions		
	Welding Conditions		
	Sorting Destinations		
6.	Butt Welding		
	Cycle Time	6 Min.	30 Min.
	Input Data		
	Fitting Position		
	Welding Conditions		
7.	Bevel Cutting		
	Cycle Time	4 Min.	10 Min.
	Input Data		
	Cutting Position		
	Cutting Speed		
8.	Pipe Bending		
	Cycle Time	4.5 Min.	10 Min.
	(2 Bent Pipe)		
	Input Data		
	Angles		
	Planes		
	Positions		
	Flange Hole Pitch		
	Diameter		
9.	Branch Pipe Welding		
	Cycle Time	10 Min.	30 Min.
	Input Data		
	Fitting Position		
	Welding Conditions		
	TOTAL	37 Min.	140 Min.

NOTE: Samples taken on 4 inch diameter standard pipe.  
. 1 6 0 w a 1 1 .

# E. Equipment Requirement

Mark	Name of System and Machine	Remarks	
1	Storage System for Raw Material		
	1-1 Elevator Selector Carriage (For Live Storage Racks)	Make	
	1-2 Live Stock Rack (1½" to 6")	Make	
	1-3 Live Storage Rack (8" to 10")	Make	
	14 Live Storage Rack	Make	
	1-5 Feed Table	Make	
	1-6 Field Pipe Storage	Make	
	1-7 Large Pipe Storage (Crane Loaded and Unloaded)	Make	
2	Surface Preparation System for Raw Material		
	2-1 Automatic Shot Blasting and Cleaning Machine (4" x 24")	Purchase and Modify	
	2-2 Automatic Painting Equipment	Purchase and Modify	
	2-3 Automatic Drying Equipment	Purchase and Modify	
3	Automatic Measuring, Cutting and Edge Preparation System		
	3-1 Edge Preparation Machine (2" to 10")	Make	
	3-2 Contouring Machine (2" to 14") (Plasma/Gas)	Available	
	3-3 Cutting Machine (1½" to 14")	Purchase	
	34 Contour Machine (8" to 24") (Plasma/Gas)	Purchase	
4	Marking System		
	4-1 Automatic Marking Machine	Make	
5	Flange Fitting and Welding Device		
	5-1 Flange Fitting and Welding Device (2" to 10")	Purchase and Modify	
	5-2 Flange Welding Machine (10" to 24")	Purchase and Modify	
6	Flange Finishing Device		
	6-1 Flange Finishing Machine (2" to 10")	Purchase	
7	Bending System		
	7-1 4" Pipe Bender	Purchase	
	7-2 8" Pipe Bender	Purchase and Modify	
	7-3 12" Pipe Bender	Purchase and Modify	
	7-4 Hot Slab	Available	
	7-5 Storage Slab	Available	
	7-6 Heating Equipment	Available	
	7-7 Sand Container and Machine	Available	
8	Contour Cutting		
	8-1 Contour Machine (2" to 10") (Plasma/Gas)	Available	
	9 Elbow and Branch Pipe Assembly, Welding System		
	9-140 and 60 Burning and Welding Branches (12" to 24")	Research and Develop/	
	9-2 High Elevated Elbow Welder (Sub-sub Assembly) (2" to 12")	Available	
	9-3 Cypress Hole Cutting and Welder Branches (2" to 14") 90 Degree	Research and Develop/	
	9-4 Final Assembly (Area)	Research and Develop/	
10	Various Types of Positioners, Manipulators and Welding Equipment		
	10-1 Double Rotators Parallel with Common Welder or Tacker (Elbow Rotation and Joint Welder) (12" to 24")	Available	
	10-2 Manipulator	Purchase and Modify	
	10-3 Elbow Rotator and Joint Welder (18" to 30")	Purchase	
	10-4 Positioner and Fit-up Rotator Station Welder (12" to 24")	Purchase	
	10-5 High Boy Rotator with 2 Variable Support Dollies for Elbows (2" to 12")	Available	
	10-6 Pipe Rotator and Welder 2 Double Dollies	Available	
	10-7 Automatic Flange Welding Machine for Short Pieces	Purchase	
11	X-Ray Facilities		
	11-1 X-ray Booth (2" to 10")	Research and Develop/	
	11-2 Conveyer (Pipe Carrier)	Available	
	11-3 Manipulator	Available	
	11-4 X-ray Booth (12" to 24")	Make	
	11-5 Conveyer (Pipe Carrier)	Available	
	11-6 Manipulator	Available	
	11-7 Scissor Jack	Purchase	
	11-8 Re-work Area	Available	
12	Pipe Handling System		
	12-1 Roller Conveyer	Purchase	
	12-2 Cross Over Rail Runner	Make	
	12-3 Pipe Kick-off Conveyer (TYP)	Purchase and Modify	
	12-4 Pipe Kick Out for Transfer Table (Typical)	Purchase and Modify	
13	Specialty Area		
	13-1 Pipe Threading Machine (1/8" to 2")	Available	
	13-2 Pipe Threading Machine (3" to 12")	Available	
	13-3 Stone Saw	Available	
	13-4 Band Saw	Available	

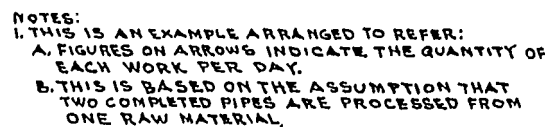




Isometric Layout of Pipe Shop Proposal

NAME OF SYSTEM / MACHINE		NAME OF SYSTEM / MACHINE	
1	1. PIPE CUTTING MACHINE (P.C.M.)	11	11. PIPE BENDING MACHINE (P.B.M.)
2	2. PIPE WELDING MACHINE (P.W.M.)	12	12. PIPE FLARING MACHINE (P.F.M.)
3	3. PIPE BENDING MACHINE (P.B.M.)	13	13. PIPE FLARING MACHINE (P.F.M.)
4	4. PIPE WELDING MACHINE (P.W.M.)	14	14. PIPE FLARING MACHINE (P.F.M.)
5	5. PIPE BENDING MACHINE (P.B.M.)	15	15. PIPE FLARING MACHINE (P.F.M.)
6	6. PIPE WELDING MACHINE (P.W.M.)	16	16. PIPE FLARING MACHINE (P.F.M.)
7	7. PIPE BENDING MACHINE (P.B.M.)	17	17. PIPE FLARING MACHINE (P.F.M.)
8	8. PIPE WELDING MACHINE (P.W.M.)	18	18. PIPE FLARING MACHINE (P.F.M.)
9	9. PIPE BENDING MACHINE (P.B.M.)	19	19. PIPE FLARING MACHINE (P.F.M.)
10	10. PIPE WELDING MACHINE (P.W.M.)	20	20. PIPE FLARING MACHINE (P.F.M.)
11	11. PIPE BENDING MACHINE (P.B.M.)	21	21. PIPE FLARING MACHINE (P.F.M.)
12	12. PIPE WELDING MACHINE (P.W.M.)	22	22. PIPE FLARING MACHINE (P.F.M.)
13	13. PIPE BENDING MACHINE (P.B.M.)	23	23. PIPE FLARING MACHINE (P.F.M.)
14	14. PIPE WELDING MACHINE (P.W.M.)	24	24. PIPE FLARING MACHINE (P.F.M.)
15	15. PIPE BENDING MACHINE (P.B.M.)	25	25. PIPE FLARING MACHINE (P.F.M.)
16	16. PIPE WELDING MACHINE (P.W.M.)	26	26. PIPE FLARING MACHINE (P.F.M.)
17	17. PIPE BENDING MACHINE (P.B.M.)	27	27. PIPE FLARING MACHINE (P.F.M.)
18	18. PIPE WELDING MACHINE (P.W.M.)	28	28. PIPE FLARING MACHINE (P.F.M.)
19	19. PIPE BENDING MACHINE (P.B.M.)	29	29. PIPE FLARING MACHINE (P.F.M.)
20	20. PIPE WELDING MACHINE (P.W.M.)	30	30. PIPE FLARING MACHINE (P.F.M.)
21	21. PIPE BENDING MACHINE (P.B.M.)	31	31. PIPE FLARING MACHINE (P.F.M.)
22	22. PIPE WELDING MACHINE (P.W.M.)	32	32. PIPE FLARING MACHINE (P.F.M.)
23	23. PIPE BENDING MACHINE (P.B.M.)	33	33. PIPE FLARING MACHINE (P.F.M.)
24	24. PIPE WELDING MACHINE (P.W.M.)	34	34. PIPE FLARING MACHINE (P.F.M.)
25	25. PIPE BENDING MACHINE (P.B.M.)	35	35. PIPE FLARING MACHINE (P.F.M.)
26	26. PIPE WELDING MACHINE (P.W.M.)	36	36. PIPE FLARING MACHINE (P.F.M.)
27	27. PIPE BENDING MACHINE (P.B.M.)	37	37. PIPE FLARING MACHINE (P.F.M.)
28	28. PIPE WELDING MACHINE (P.W.M.)	38	38. PIPE FLARING MACHINE (P.F.M.)
29	29. PIPE BENDING MACHINE (P.B.M.)	39	39. PIPE FLARING MACHINE (P.F.M.)
30	30. PIPE WELDING MACHINE (P.W.M.)	40	40. PIPE FLARING MACHINE (P.F.M.)
31	31. PIPE BENDING MACHINE (P.B.M.)	41	41. PIPE FLARING MACHINE (P.F.M.)
32	32. PIPE WELDING MACHINE (P.W.M.)	42	42. PIPE FLARING MACHINE (P.F.M.)
33	33. PIPE BENDING MACHINE (P.B.M.)	43	43. PIPE FLARING MACHINE (P.F.M.)
34	34. PIPE WELDING MACHINE (P.W.M.)	44	44. PIPE FLARING MACHINE (P.F.M.)
35	35. PIPE BENDING MACHINE (P.B.M.)	45	45. PIPE FLARING MACHINE (P.F.M.)
36	36. PIPE WELDING MACHINE (P.W.M.)	46	46. PIPE FLARING MACHINE (P.F.M.)
37	37. PIPE BENDING MACHINE (P.B.M.)	47	47. PIPE FLARING MACHINE (P.F.M.)
38	38. PIPE WELDING MACHINE (P.W.M.)	48	48. PIPE FLARING MACHINE (P.F.M.)
39	39. PIPE BENDING MACHINE (P.B.M.)	49	49. PIPE FLARING MACHINE (P.F.M.)
40	40. PIPE WELDING MACHINE (P.W.M.)	50	50. PIPE FLARING MACHINE (P.F.M.)
41	41. PIPE BENDING MACHINE (P.B.M.)	51	51. PIPE FLARING MACHINE (P.F.M.)
42	42. PIPE WELDING MACHINE (P.W.M.)	52	52. PIPE FLARING MACHINE (P.F.M.)
43	43. PIPE BENDING MACHINE (P.B.M.)	53	53. PIPE FLARING MACHINE (P.F.M.)
44	44. PIPE WELDING MACHINE (P.W.M.)	54	54. PIPE FLARING MACHINE (P.F.M.)
45	45. PIPE BENDING MACHINE (P.B.M.)	55	55. PIPE FLARING MACHINE (P.F.M.)
46	46. PIPE WELDING MACHINE (P.W.M.)	56	56. PIPE FLARING MACHINE (P.F.M.)
47	47. PIPE BENDING MACHINE (P.B.M.)	57	57. PIPE FLARING MACHINE (P.F.M.)
48	48. PIPE WELDING MACHINE (P.W.M.)	58	58. PIPE FLARING MACHINE (P.F.M.)
49	49. PIPE BENDING MACHINE (P.B.M.)	59	59. PIPE FLARING MACHINE (P.F.M.)
50	50. PIPE WELDING MACHINE (P.W.M.)	60	60. PIPE FLARING MACHINE (P.F.M.)
51	51. PIPE BENDING MACHINE (P.B.M.)	61	61. PIPE FLARING MACHINE (P.F.M.)
52	52. PIPE WELDING MACHINE (P.W.M.)	62	62. PIPE FLARING MACHINE (P.F.M.)
53	53. PIPE BENDING MACHINE (P.B.M.)	63	63. PIPE FLARING MACHINE (P.F.M.)
54	54. PIPE WELDING MACHINE (P.W.M.)	64	64. PIPE FLARING MACHINE (P.F.M.)
55	55. PIPE BENDING MACHINE (P.B.M.)	65	65. PIPE FLARING MACHINE (P.F.M.)
56	56. PIPE WELDING MACHINE (P.W.M.)	66	66. PIPE FLARING MACHINE (P.F.M.)
57	57. PIPE BENDING MACHINE (P.B.M.)	67	67. PIPE FLARING MACHINE (P.F.M.)
58	58. PIPE WELDING MACHINE (P.W.M.)	68	68. PIPE FLARING MACHINE (P.F.M.)
59	59. PIPE BENDING MACHINE (P.B.M.)	69	69. PIPE FLARING MACHINE (P.F.M.)
60	60. PIPE WELDING MACHINE (P.W.M.)	70	70. PIPE FLARING MACHINE (P.F.M.)
61	61. PIPE BENDING MACHINE (P.B.M.)	71	71. PIPE FLARING MACHINE (P.F.M.)
62	62. PIPE WELDING MACHINE (P.W.M.)	72	72. PIPE FLARING MACHINE (P.F.M.)
63	63. PIPE BENDING MACHINE (P.B.M.)	73	73. PIPE FLARING MACHINE (P.F.M.)
64	64. PIPE WELDING MACHINE (P.W.M.)	74	74. PIPE FLARING MACHINE (P.F.M.)
65	65. PIPE BENDING MACHINE (P.B.M.)	75	75. PIPE FLARING MACHINE (P.F.M.)
66	66. PIPE WELDING MACHINE (P.W.M.)	76	76. PIPE FLARING MACHINE (P.F.M.)
67	67. PIPE BENDING MACHINE (P.B.M.)	77	77. PIPE FLARING MACHINE (P.F.M.)
68	68. PIPE WELDING MACHINE (P.W.M.)	78	78. PIPE FLARING MACHINE (P.F.M.)
69	69. PIPE BENDING MACHINE (P.B.M.)	79	79. PIPE FLARING MACHINE (P.F.M.)
70	70. PIPE WELDING MACHINE (P.W.M.)	80	80. PIPE FLARING MACHINE (P.F.M.)
71	71. PIPE BENDING MACHINE (P.B.M.)	81	81. PIPE FLARING MACHINE (P.F.M.)
72	72. PIPE WELDING MACHINE (P.W.M.)	82	82. PIPE FLARING MACHINE (P.F.M.)
73	73. PIPE BENDING MACHINE (P.B.M.)	83	83. PIPE FLARING MACHINE (P.F.M.)
74	74. PIPE WELDING MACHINE (P.W.M.)	84	84. PIPE FLARING MACHINE (P.F.M.)
75	75. PIPE BENDING MACHINE (P.B.M.)	85	85. PIPE FLARING MACHINE (P.F.M.)
76	76. PIPE WELDING MACHINE (P.W.M.)	86	86. PIPE FLARING MACHINE (P.F.M.)
77	77. PIPE BENDING MACHINE (P.B.M.)	87	87. PIPE FLARING MACHINE (P.F.M.)
78	78. PIPE WELDING MACHINE (P.W.M.)	88	88. PIPE FLARING MACHINE (P.F.M.)
79	79. PIPE BENDING MACHINE (P.B.M.)	89	89. PIPE FLARING MACHINE (P.F.M.)
80	80. PIPE WELDING MACHINE (P.W.M.)	90	90. PIPE FLARING MACHINE (P.F.M.)
81	81. PIPE BENDING MACHINE (P.B.M.)	91	91. PIPE FLARING MACHINE (P.F.M.)
82	82. PIPE WELDING MACHINE (P.W.M.)	92	92. PIPE FLARING MACHINE (P.F.M.)
83	83. PIPE BENDING MACHINE (P.B.M.)	93	93. PIPE FLARING MACHINE (P.F.M.)
84	84. PIPE WELDING MACHINE (P.W.M.)	94	94. PIPE FLARING MACHINE (P.F.M.)
85	85. PIPE BENDING MACHINE (P.B.M.)	95	95. PIPE FLARING MACHINE (P.F.M.)
86	86. PIPE WELDING MACHINE (P.W.M.)	96	96. PIPE FLARING MACHINE (P.F.M.)
87	87. PIPE BENDING MACHINE (P.B.M.)	97	97. PIPE FLARING MACHINE (P.F.M.)
88	88. PIPE WELDING MACHINE (P.W.M.)	98	98. PIPE FLARING MACHINE (P.F.M.)
89	89. PIPE BENDING MACHINE (P.B.M.)	99	99. PIPE FLARING MACHINE (P.F.M.)
90	90. PIPE WELDING MACHINE (P.W.M.)	100	100. PIPE FLARING MACHINE (P.F.M.)





## J. Specification of Equipment and Machines with Concept Drawings

Each specification and concept drawing has been assigned a number. This number is a locator number which is identical to the equipment number shown on the plan view and isometric layout of the Pipe Shop, Drawing 031-M76-8-2, Sheets 11 and 12 respectively. The purpose of the numbering system is to provide the reader with a quick reference from the layouts to the detail conceptual drawings, or vice versa.

### 1-1 Elevator Type Storage

Number of Set:	3
Stored Pipe	
Nominal Size:	1½" - 6"      8" - 10"
Length:	Single Random
Kind of Pipe:	32(4 kinds x 8)
Number of Pipe:	1208 (totally in case 1½ - 6" pipes only)

#### Function & Control

Up-down drive of pick-up device; rack and pinion drive by electric motor

Push-pull motion drive of pick-up device; pneumatic cylinder

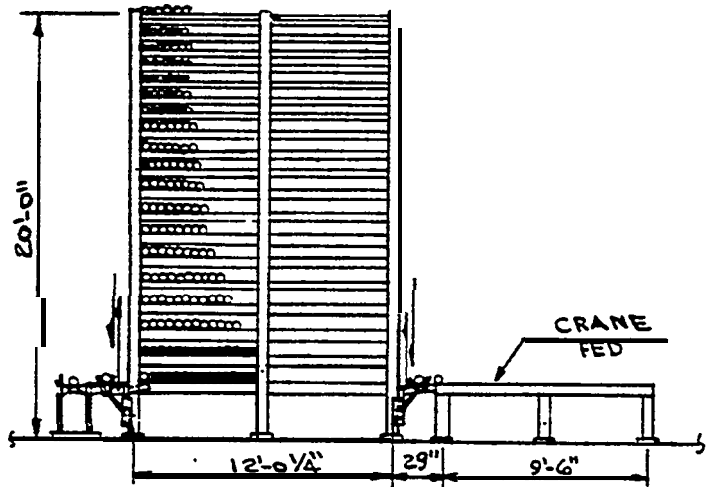
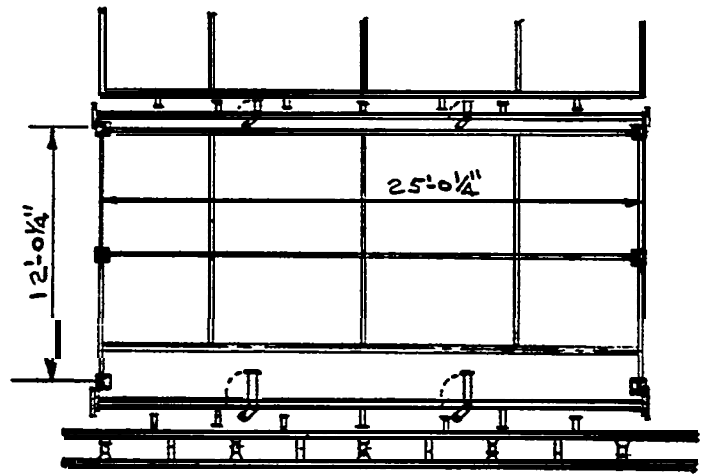
Positioning of pick-up device; automatically by limit switch

Loading table; gravity fed-hydraulic-kick outs

Pipes are loaded on the loading table by crane.

A pipe is selected out according to instructions of the pushbutton on the operation desk for the shot blasting machine.

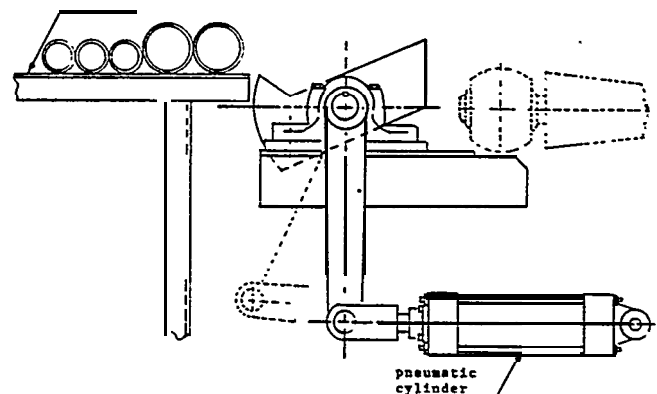
Selected pipe on the skid is transported to roller conveyor by means of transferring device furnished in the elevator type storage.



*Elevator Type Storage Rack*

### 1-2 Skid Type Storage

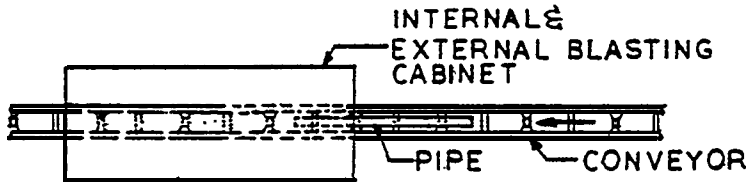
Number of Set	3
Stored Pipe	
Nominal size:	12"/24"
Length:	Random
Number of Pipe:	16 (in case of 18")
Function & Control	
Area of skid	20' X 26'
Pick up device:	Driven by pneumatic cylinder. Pipes are arranged on the skid according to the order to be processed a day. One pipe is taken out on the roller conveyor by pushing button. It is controlled from shot blasting machine.



*Skid type storage with pick up device*



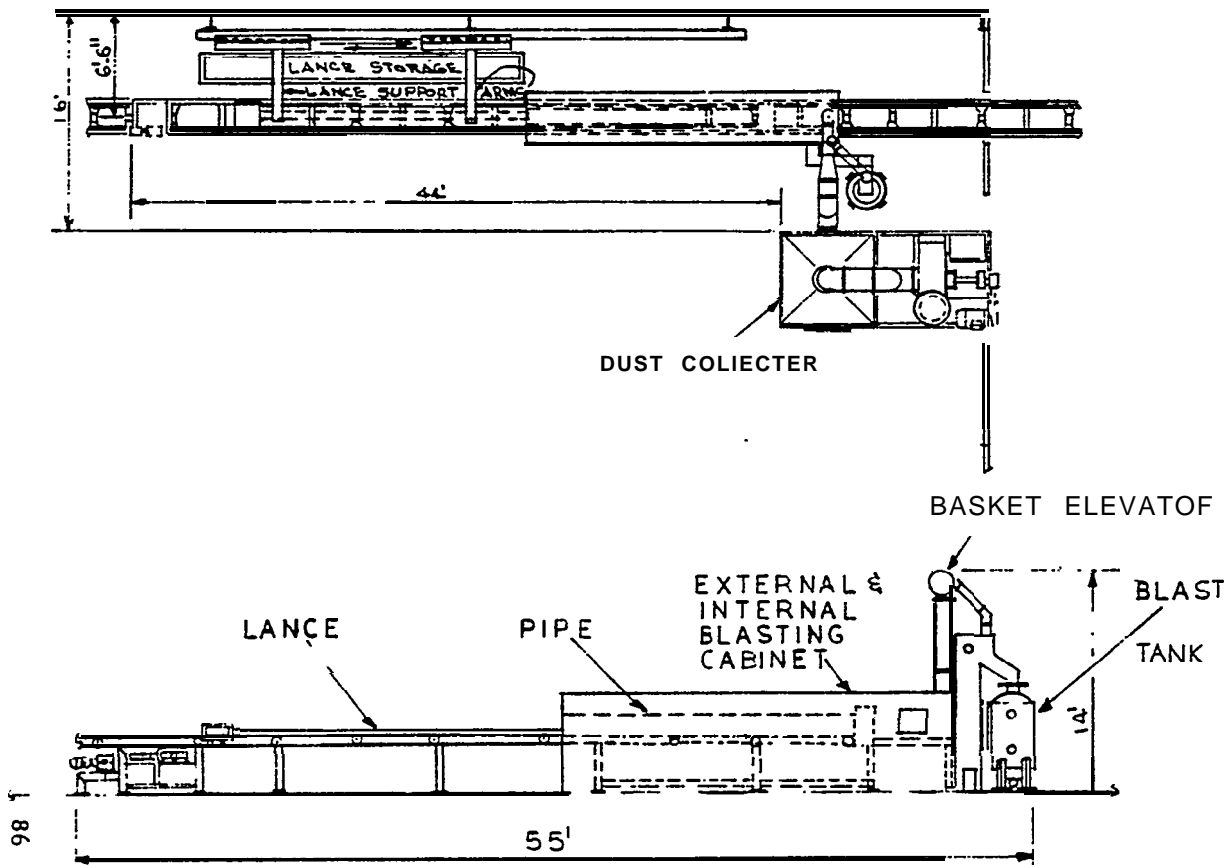
- 2- Surface Preparation System for Raw Material
- 2-1 Automatic Shot Blasting Machine
- By this method the internal and external pipe surfaces are blasted. When internal blasting is not required, by-pass the lance
- Number of Set One:
- Applied Pipe
- Diameter 1 1/2" - 24"
- Length: Max. Random
- Method Nozzle & Lance



Composition	
Grits collector	One Set
Bucket elevator	One
Blast tank (two steps continuous work type)	One
Abrasive hose and nozzle (Nozzle dia. 5/8")	Four
Grit shield with sliding mechanism	One
Dust collector	One
Pipe feeding and ejecting device	One
Abrasive material	steel grit

Function

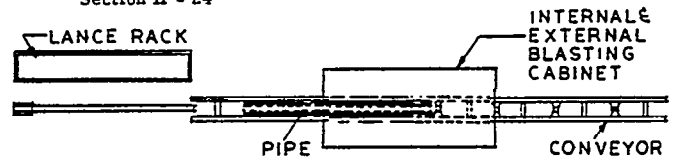
Pipe is automatically fed to external blasting



Surface Preparation System for Raw Material

cabinet on conveyor. At the point when the pipe enters the blasting cabinet the conveyor feed speed is semi-automatically matched to blasting speed and blasting begins. Blasting continues as pipe passes through the blasting cabinet.

Section II - 24



When the pipe is in the position shown above, external blasting is completed. The conveyor and blasting function automatically stops. The appropriate lance is selected, positioned and fed through the inside of the pipe. Lance speed and blasting injection rate is matched to obtain specified surface preparation. After the lance has traveled the pipe length, internal blasting is complete, the lance is backed out and positioned in the lance rack automatically. The residual blast media is automatically discharged into the external blasting cabinet for recovery.

#### Operation

After the pipe on the conveyor is fed in the machine via push buttons and select switches from the operation desk, pipe setting and blasting work is done automatically.

Manual operation of each sequence via push button is also possible.

## 2-2 Painting Equipment

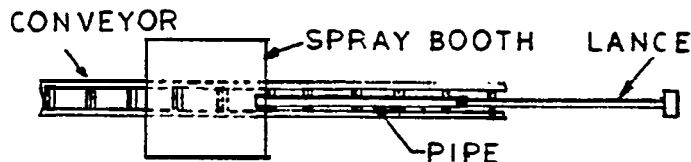
Internal coating is applied, if required, in the first step of this process.

Number of Set One

Applied Pipe

Diameter: 2" -36"

Length: Max. Random



The pipe is positioned as shown above automatically with the leading end of the pipe just inside the spray booth. The spray lance is selected from the lance storage area and positioned automatically using push button controls. The lance travels through the pipe; spraying starts automatically using a limit switch; the lance travel speed is matched to spray system with variable preselect push button control for application on different types of coatings. When the lance passes through the work piece, spray starts as the lance is backed out, then returns to storage automatically.

When the lance is returned to storage, the external

coating system starts automatically. The pipe is carried through the spray booth on slat conveyor. Spraying starts automatically. If internal coating is not required, the internal coating process is bypassed.

Composition:

Spray booth

Airless spray system with two guns for external painting

Spray flange fitted with appropriate nozzles and travel mechanism for internal coatings.

Slat chain conveyor with drive system and push button control.

Function

Conveyer speed: 15 feet per minute

Airless spray system

Electro mechanical device for automatic controls.

Pneumatic device lance storage.

2-3

## Drying Equipment

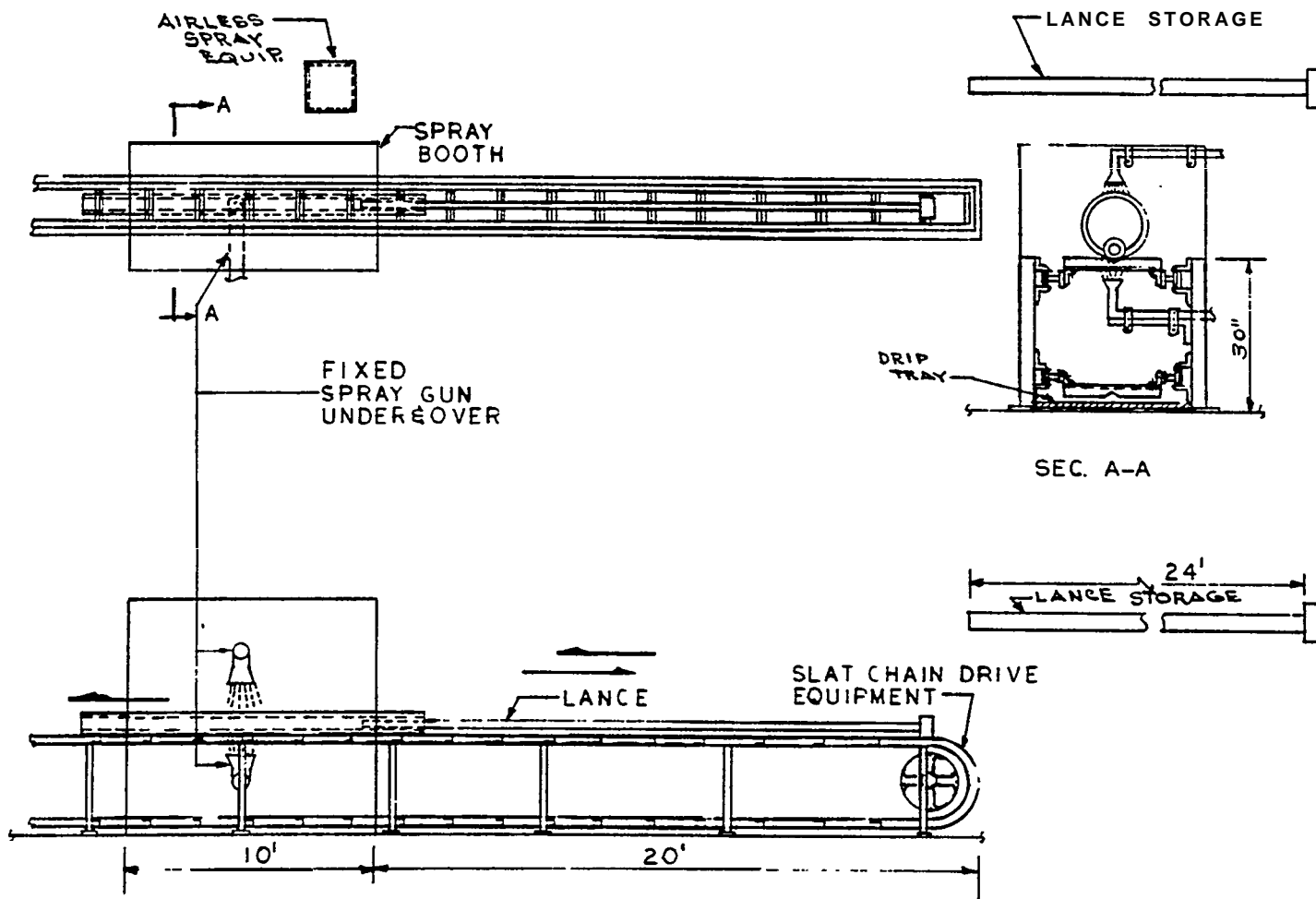
By adopting an infrared dry oven this process can be accomplished quickly and economically.

Number of Set One

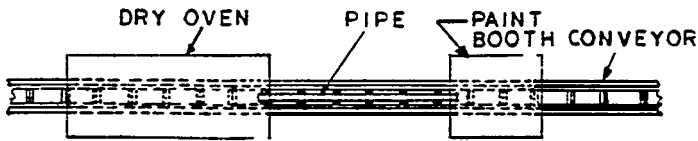
Applied Pipe

Diameter: 2" -36"

Length: Max. Random



Painting Equipment



An infrared drying oven positioned the appropriate distance from the paint booth, fitted with push button controls and limit switches, bring the oven up to operation temperature employing speed control. Slat conveyor will cure the coating by the time the pipe passes through the oven.

A device is installed on the exit end of the oven to automatically stamp the pipe alloy identification on the pipe piece as it passes.

A touch up area is required for coating the pipe where it was resting on the slat conveyor. This is a manual operation.

**Composition:**

240 infrared panels

Operating

Temperature: 375 Deg. F

Slat Conveyor Speed: 15 feet/min.

Automatic controls: Electro/mechanical

3. Automatic Measuring, Cutting & Edge Preparation System.

3-1 Edge Preparation Machine (2"-10")

Number of Set: One

Applied Pipe

Nominal Size 2" -10"

Length: 2'-20'

Material: Carbon steel, alloy steel, stainless steel, copper-nickel

**Edge preparation method**

Mechanical edge preparation by rotation of cutting tool with clamping of pipe.

**Function & Control**

Chuck: Automatic centering and chucking mechanism

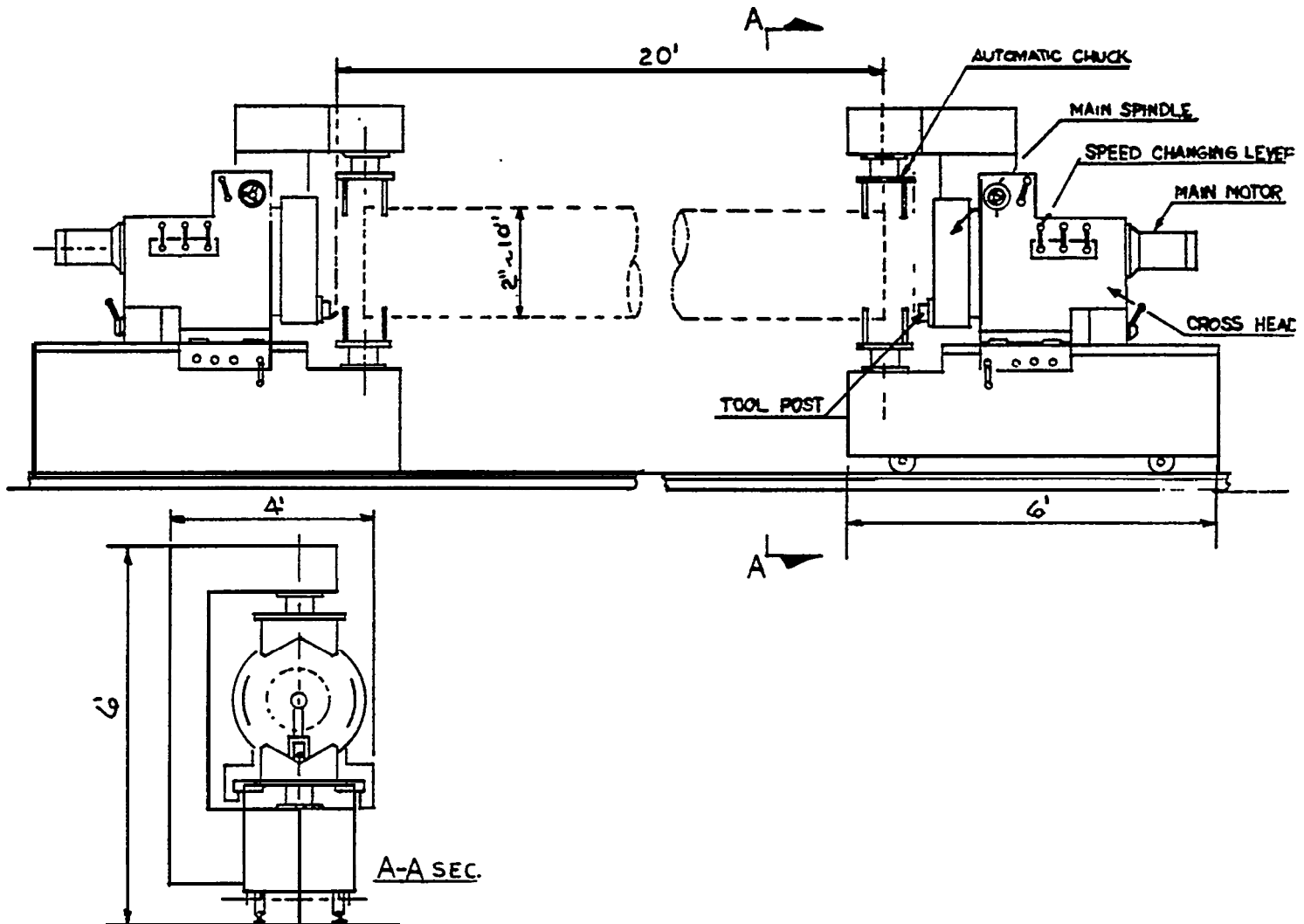
Setting of cutting tool to pipe end:  
Manually by handle

Machining: By automatic cutting feed of cross head and tool post.

Changing of automatic feed speed:  
Manually by lever

**Operation**

Push button and manually



Edge Preparation Machine

3-2

### Contouring Machine

This machine provides the versatility of contour cutting the various alloys with simultaneous beveling.

Number of Set: 3  
 Applied Pipe  
 Material: Carbon steel, stainless steel, etc.  
 Diameter: 2"- 10"; 2"- 14"; 8"-24"  
 Thickness: .156 -.624  
 Length: 20 feet

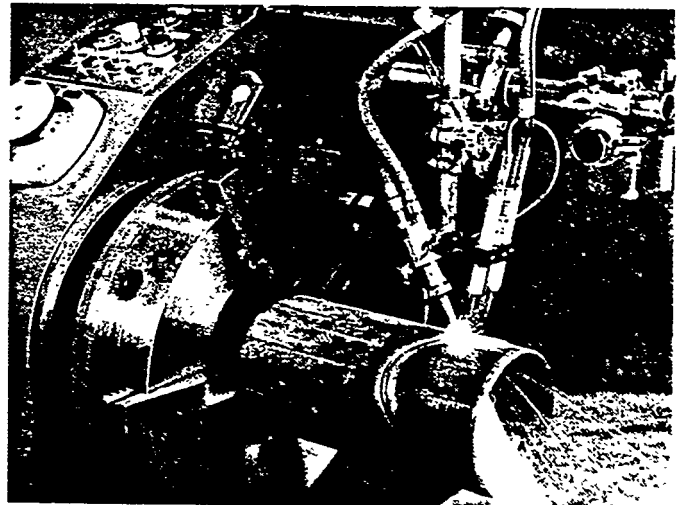
#### Composition

Power source: Max. 500A (D.C. dropping characteristics)  
 Secondary load voltage: 200V or 400V  
 Fume exhaust device  
 Air compressor for plasma  
 Torch positioning device: manipulator, sensor, guider consumable parts:  
 electrode 2-4 hours.  
 nozzle 1-3 hours.

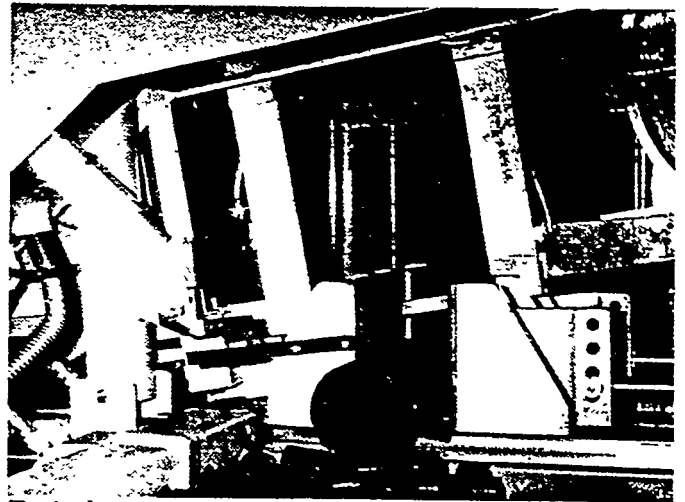
Optional select standard gas cutting system.

#### Operation

The pipe fed from conveyer by push button shall be set and cut via push button controls.



*Typical contouring machine.*



*Typical saw type cutting machine.*

### 3-3 Cutting Machine

This machine automatically saws pipe to length leaving a square clean cut of which beveling will be applied at another work station.

Number of Set: One  
 Applied Pipe  
 Normal Size: 1½" - 14"  
 Length: 2-20 Feet  
 Material: Carbon steel, stainless steel, copper, copper-nickel, etc.

#### Cutting Method:

Mechanical cutting by means of high speed saw.

#### Function & Control:

#### Measuring of cutting length:

Pipe is selected and positioned under saw in appropriate position by push button control using end stop preset by means of manual digital switch stopping pipe at desired length for cutting.

#### Scrap Pipe Removal:

By automatic scrap conveyer

#### Operation:

A series of automatic operations in accordance with the instructions of push button operation by the operator.

4

### Automatic Marking Machine

The paint spray method of marking can be done on pipes of any material and the size of figures is changeable.

Number of Set: One  
 Applied Pipe  
 Diameter: 1½" -24"

#### Method

Paint spray method

#### Composition

Paint unit  
 Control box and electric solenoid valves  
 Moveable spray guns with two motors

#### Function

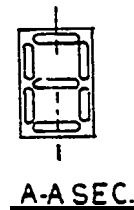
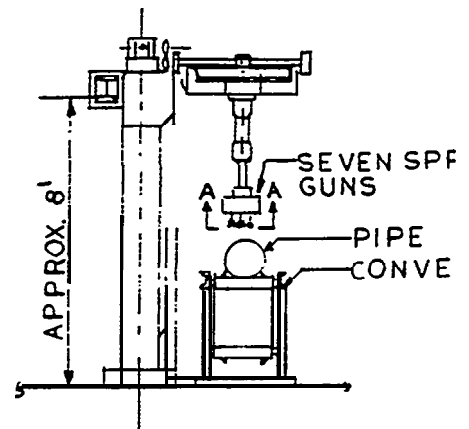
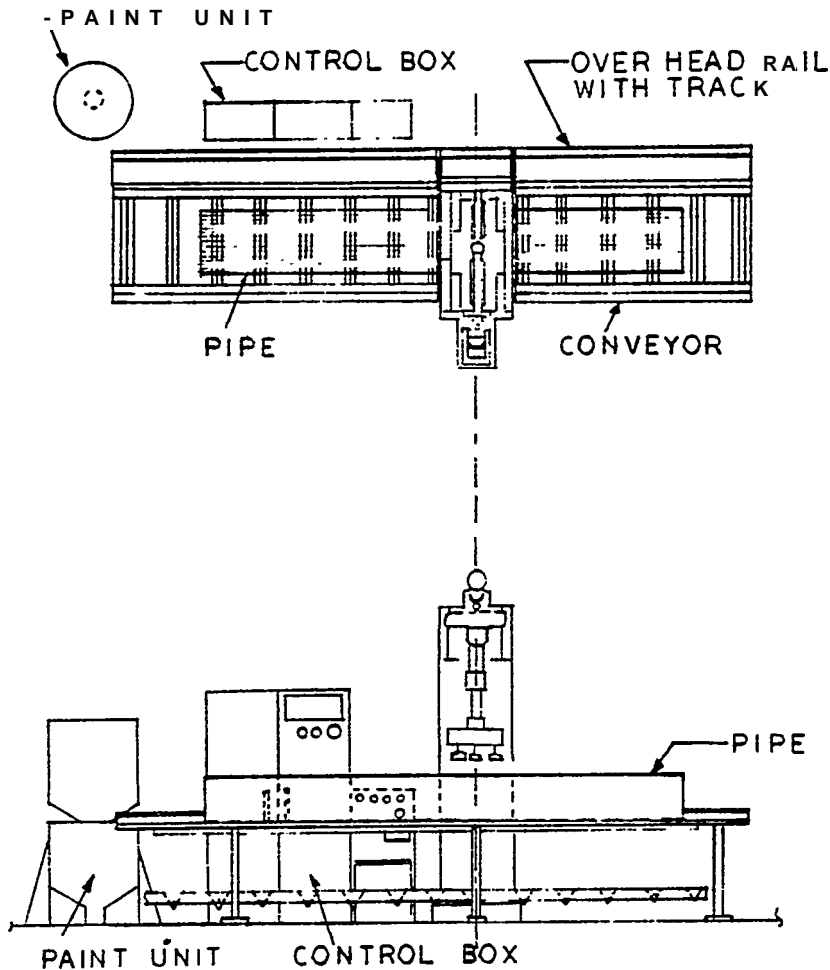
Figures from zero to nine can be marked as being arranged.

#### Control:

Number and size of figures are preset via select switches.

Figures are marked individually by keying in of respective buttons.

Automatic operation is possible in accordance with instructions from NC card from disk type cutting machine.



### Marking Machine

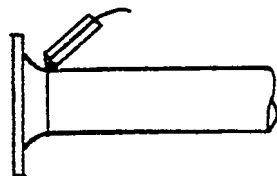
#### 5 Flange Fitting & Welding

##### 5-1 Flange Fitting & Welding Machine

This machine must be designed for semi-automatically fitting weld neck flanges as well as slip on flanges. The welding method shall be quick change automatic gas metal arc/or Tig as comports materials involved.

Number of Set: One  
 Material: Steel, CR-MO Steel, Stainless Steel, etc.  
 Diameter: 2" - 10"  
 Length: 2' - 20'

##### 5-1A TIG Method (TIG)



#### Composition

Power source: D. C./A.C. 300A

Fixed type manipulator

Moveable type manipulator

Pipe support rollers with rotation mechanism

#### Operation

Pipe and welding condition would be preset via select switches.

Torch positioning and welding are done automatically in the suitable condition by Arc Voltage controls and Auto groove detector after setting manually via push button.

##### 5-1B NC flange fitting & welding machine

This machine is specially designed for automatically fitting and welding pipe and flanges in accordance with the instruction of NC control desk.

#### Applied Pipe and Flange

Normal size: 2" - 10"

Length of Pipe: 2' - 20'

Material: Steel

Type of Flange: Slip on weld, 150 LB, 300 LB

#### Function & Control

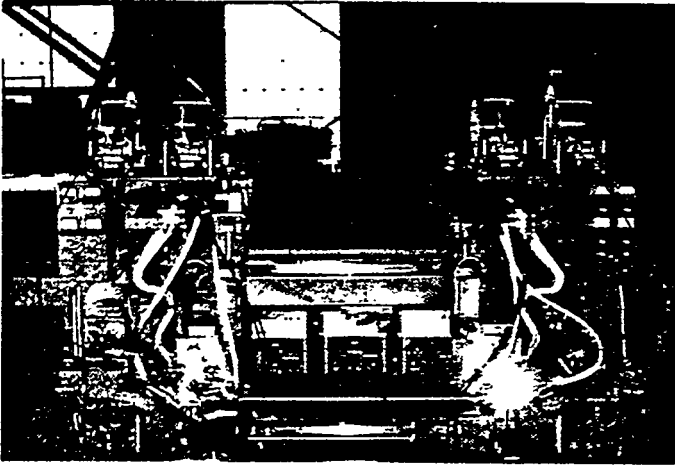
Numerical control axes; 10 axes  
Positioning of moveable saddle x 1  
Positioning of flange bolt hole detector x 2  
Positioning of jaws x 6  
Differential angle of flange bolt holes between both sides x 1

#### Tacking and welding:

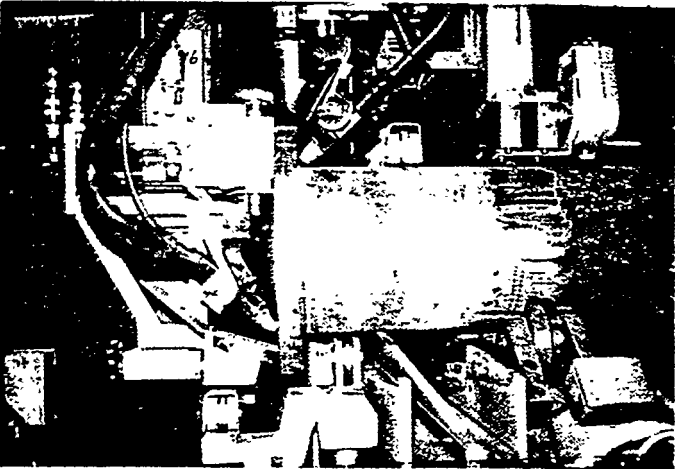
Automatic GMA welding machine  
Fine adjusting of continuous welding is manually done, if necessary.

#### Operation

Pipe and flanges, conveyed through pipe cutting machine and flange storage and selector respectively, is automatically fitted and welded by this machine in accordance with instructions of NC card.



*Typical flange welding machine.*



*Close up view of flange welding machine.*

#### 5-1 C Flange Storage & Selector

Number of Set	One
Stored Flange	
Normal Size:	2" -10"
Material:	Steel, CR-MO, Stainless Steel, etc.
Type:	Slip on weld, 150 LB, 300 LB
Kind of flange:	18(9 kinds x 2)

#### Function & Control

Loading flanges in storage:

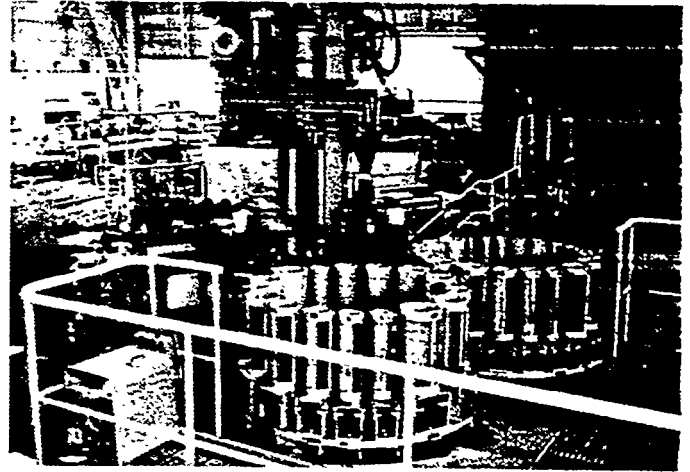
Manually by using loading jig and crane.

Taking out method:

Pushing by pneumatic cylinder

Control:

Automatic operation/  
required flange is selected out in accordance with the instruction of NC card for NC flange fitting and welding machine.

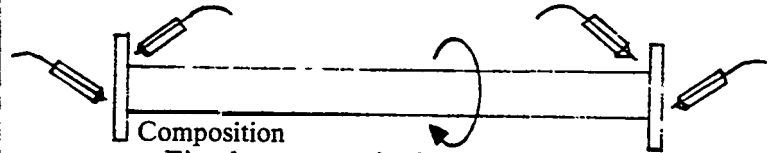


*Typical flange storage and selector device.*

#### 5-2A GMA Flange Welding Machine

By employing 4 torches-concurrent-work method the welding of inside and outside of flange on both sides is done simultaneously.

Number of set:	One
Applied Pipe and Flange	
Material:	Carbon Steel
Diameter:	12" - 24"
Length:	3'-20'
Thickness:	Weight class STD, XS
Method	
4 torches-concurrent-work GMA Welding method	



Composition

Fixed type manipulator with two welding torches, sensors and guides

Movable type manipulator with two welding torches, sensors and guides

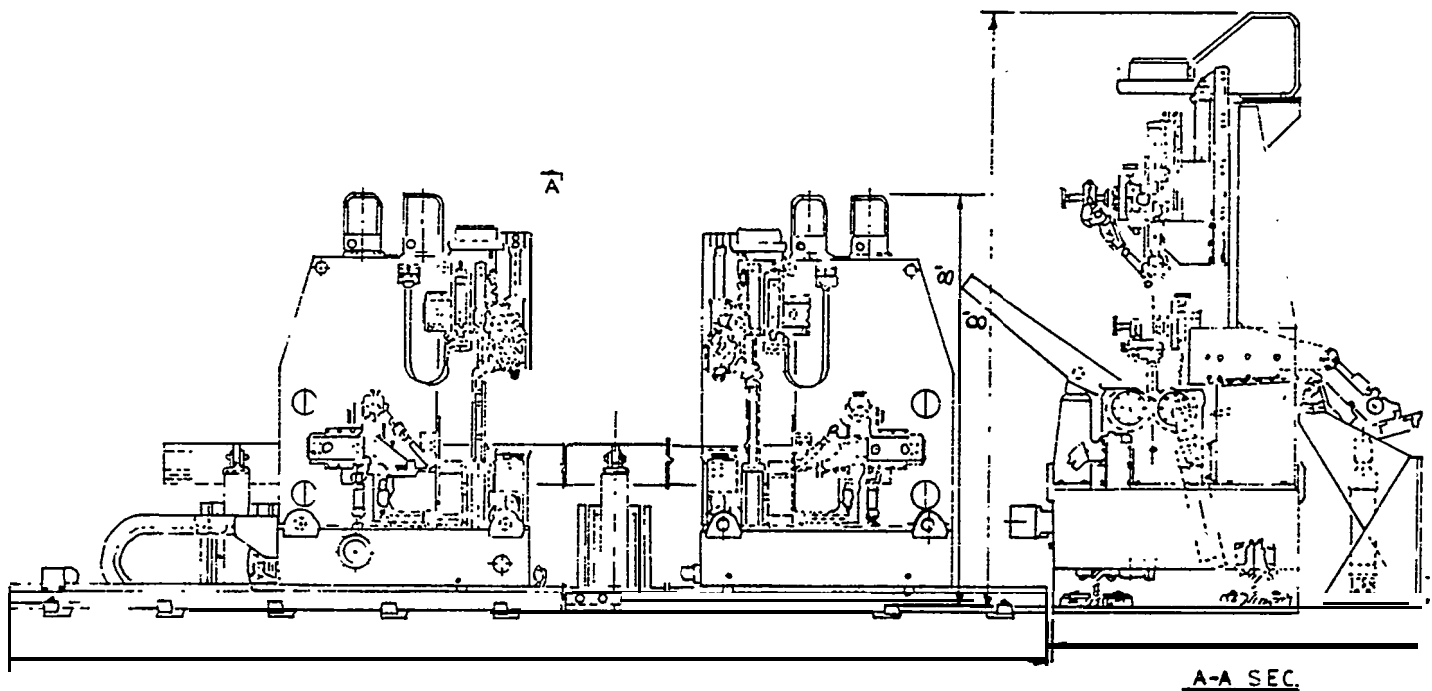
Support rollers with rotation mechanism

#### Operation

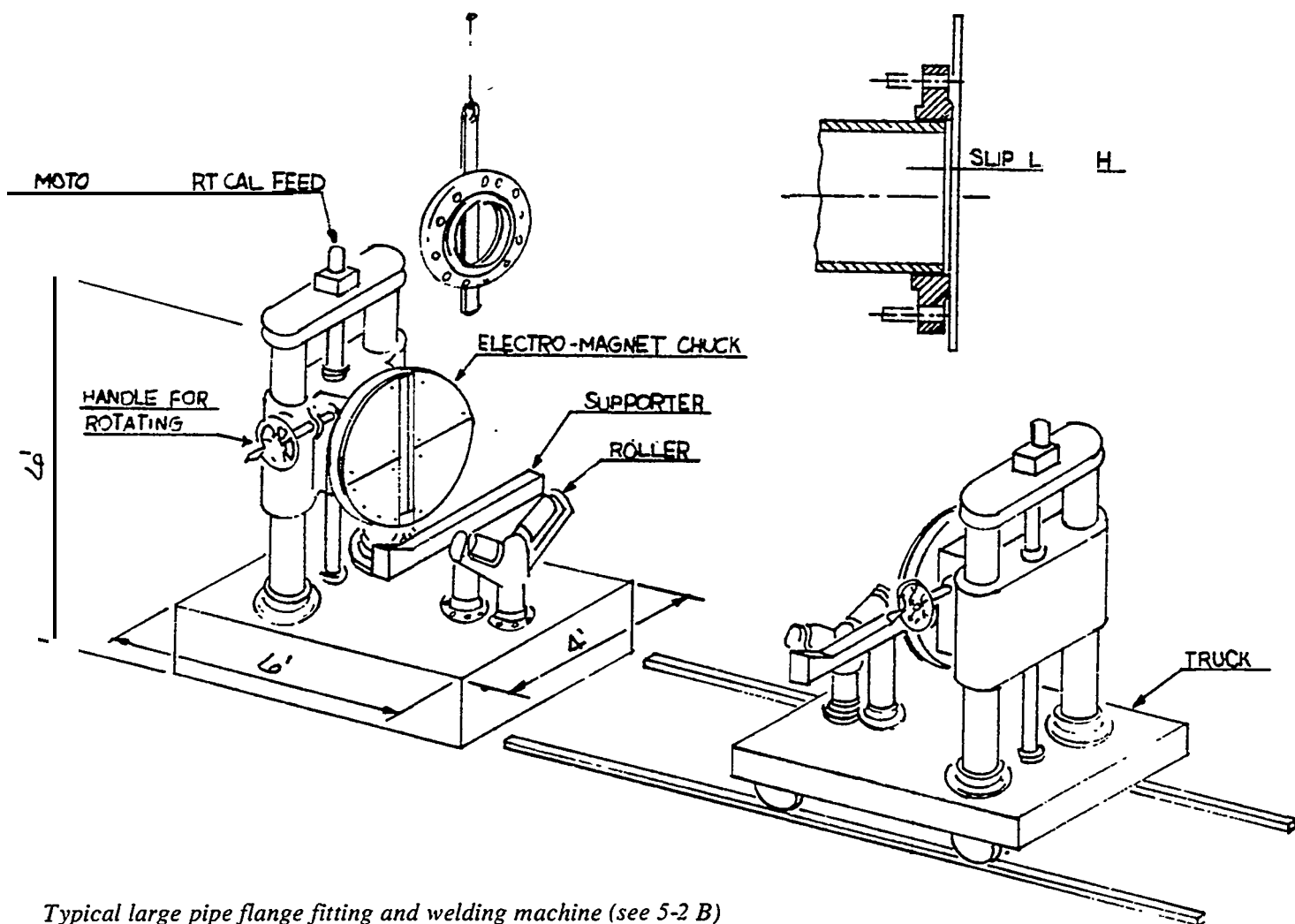
Pipe feed and take-out work is done via push buttons

Electric current, voltage, welding speed and arc time are preset via select switches

Torch positioning and welding are done automatically in the suitable condition by mechanical guide sensors.



*GMA Flange Welding Machine*



*Typical large pipe flange fitting and welding machine (see 5-2 B)*

## 5-2B Flange Fitting Machine

Number of set: One  
 Applied Pipe and Flange  
 Nominal size: 12"-24"  
 Length of Pipe: 3'-20'  
 Material of pipe and flange: steel  
 Type of Flange: Slip on weld 150 LB & 300 LB

### Composition

Fix and moveable carriage, semi-auto GMA welding equipment for tack welding flange.

### Function & Control

Inserting flange in chuck

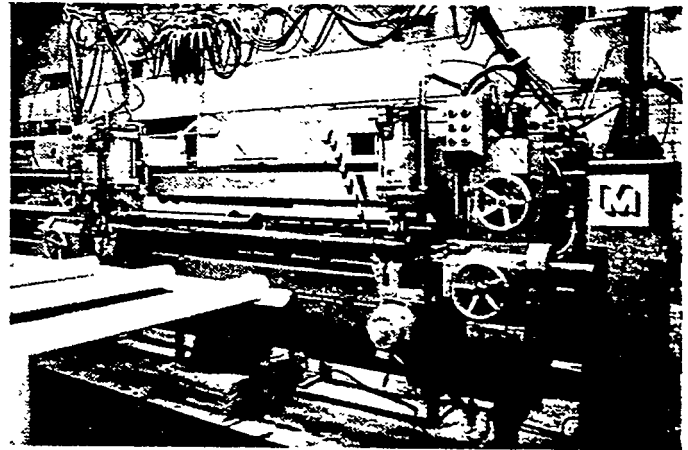
By exclusive hoist

Chucking method: By electro-magnet chuck

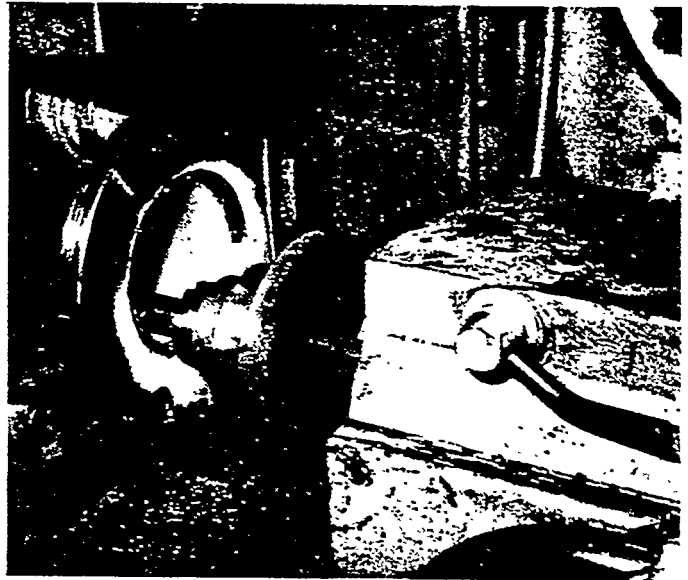
Adjusting jig: To be prepared for each kind of flange. By only setting the flanges by using adjusting jig; the relative position of bolt holes between both flanges is mechanically in the same position and lip length is exactly decided.

Tack-welding: Manually by using semi-automatic GMA welding machines

Operation: By push-button and manual



*Typical flange finishing machine.*

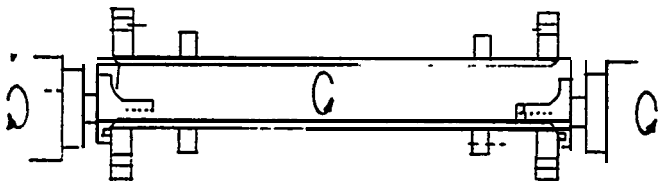


*Close up view flange finishing machine.*

## 6 Flange Finishing

### 6-1 Flange Finishing Machine

Number of Set: One  
 Applied Pipe and Flange  
 Nominal size: 2" - 10"  
 Length of Pipe: 1'-20'  
 Material: Steel, CR-MO Steel, Stainless Steel, etc.  
 Type of Flange: Slip on weld, 150 LB, 300 LB  
 Finishing Method: By bore and face milling cutter with pipe rotation



### Control & Operation

Carriage is automatically positioned by detection of pipe length with limit switch. Setting of cutters is manually controlled.

Machining of inside welded part and cleaning of spatter is concurrently earned out at both ends.

## 7. Bending System with Loading & Unloading Devices

### 7-1A Automatic pipe loader

The machine is designed for automatically transporting and loading the pipe from the pipe skid to the suitable position of NC 4" pipe bender.

Number of Set: One

Applied Pipe

Nominal size: 2" - 4"

Length: 2' - 20'

Shape: Straight without flange

Operation & Control

Automatic

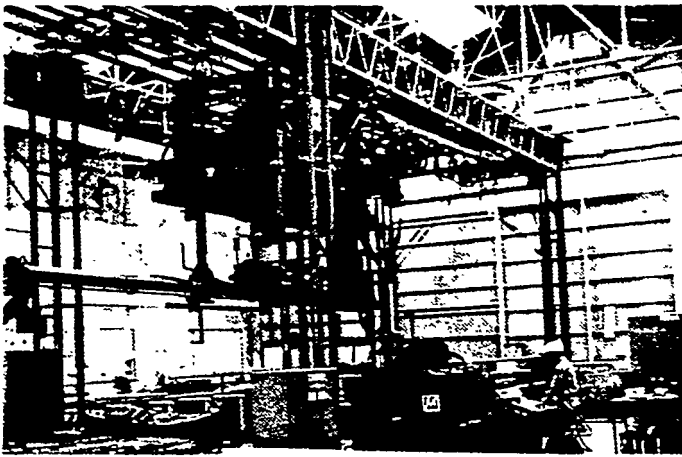
operation:

A series of movement is earned out in accordance with the preset sequence combined with NC 4" bender. Positioning to catch size pipe by limit switches.

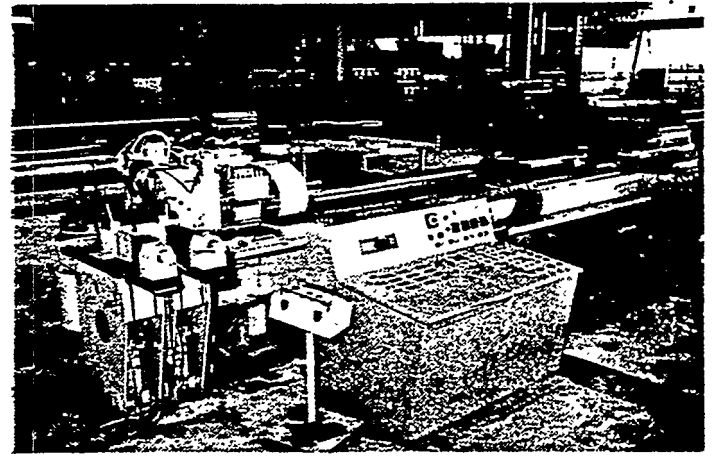
Manual operation:

Control by using the push button on the operation desk.





*Typical bending machine loading device.*



*Typical N.C. 4 inch bending machine.*

#### 7-IB NC 4" pipe bender

This machine is designed to bend automatically the pipe in three dimensions in accordance with the instructions of numerical control combined with automatic pipe loader.

Number of Set One

Applied Pipe and Flange 2" - 4"

Nominal-size:

Length of Pipe: 2'-20"

Shape of Pipe: Straight with/without flange

Thickness of pipe: .11- .34 inch

Material of pipe & flange: Carbon Steel, stainless steel, copper, copper-nickel, etc.

Function & Control  
Numerical Control  
axes:

4 axes-measuring pipe feed length, rotation angle of pipe, bending angle, and positioning of flange bolt hold detector.

Bending speed:

Bending: 2 steps changeable  
Approx. 2 x out dia.  
(General)

Mandrel: Plug type and ball type

Pressure dia

Chucking

Equipment

For positioning and rotating of pipe. Furnished flange bolt hole detector.

Correction of  
spring back

Program input (NC card) or manual input by digital switch.

Operation

Automatic

Operation

A series of three-bending (max.) is carried out according to the instructions of preset sequence and data input by NC card or NC tape.

Semi-automatic

Operation:

One-bending is carried out in accordance with the data input by digital switch.

Manual Operation: Control by the push-button on control console.

#### 7-2A Automatic Pipe Loader, 6" - 8"

This machine is similar to that of 7-1A

Number of Set: One

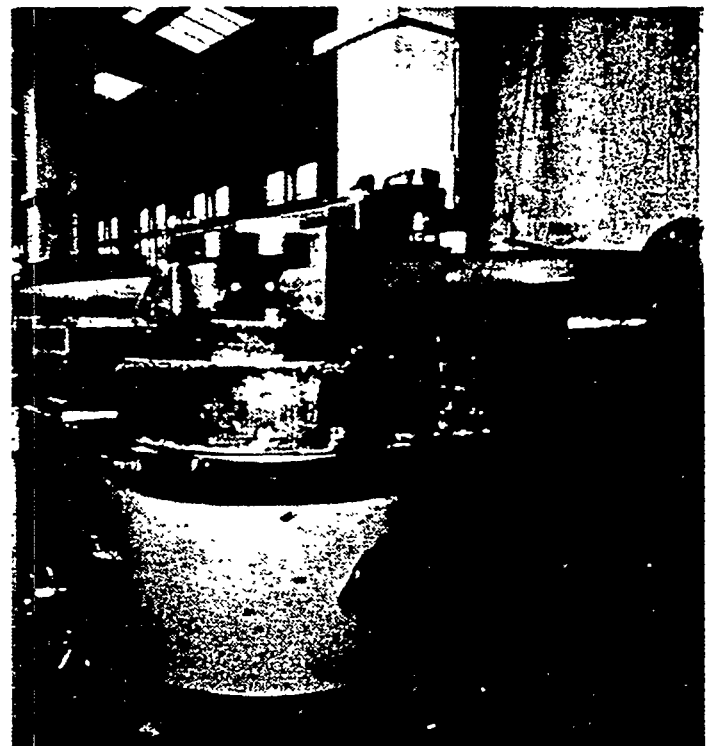
Applied Pipe and Flange 6" - 8"

Nominal:

Length of Pipe: 3'-20'

Shape: Straight with/without flange

Operation: Same as 7-1A



*Typical flange on bending machine.*

### 7-2B NC 8" Pipe Bender

This machine is similar to that of 7-1B.

Number of Set: One  
 Applied Pipe and Flange: 8" - 8"  
 Nominal Size: 8"  
 Length of Pipe: 3' - 20'  
 Shape of Pipe: straight with/without flange  
 Thickness of Pipe: .12-.4 (General)  
 Material of Pipe and Flange: Carbon Steel, Stainless Steel, Copper, Copper Nickel, etc.  
 Function and Control: Same as 7-1B.

### 7-3B NC 12" Pipe bender

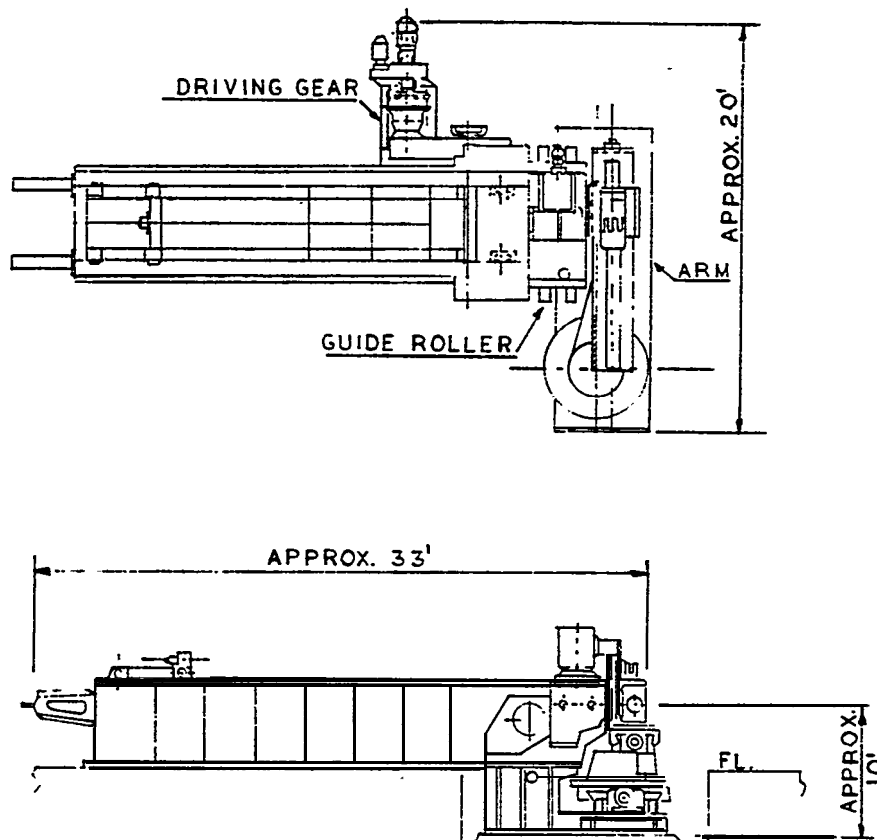
This machine is similar to that of 7-1B

Number of Set: One  
 Applied Pipe and Flange: 8" / 12"  
 Nominal Size: 8" / 12"  
 Length of Pipe: 3' - 20'  
 Shape of Pipe: Straight with/without flange  
 Thickness of Pipe: .138 -.495" (general)  
 Material of pipe & flange: Carbon steel, stainless steel, copper, copper-nickel, etc.  
 Function, Control & Operation is the same as 7-1B.

### 7-3A Automatic pipe loader (8" - 12")

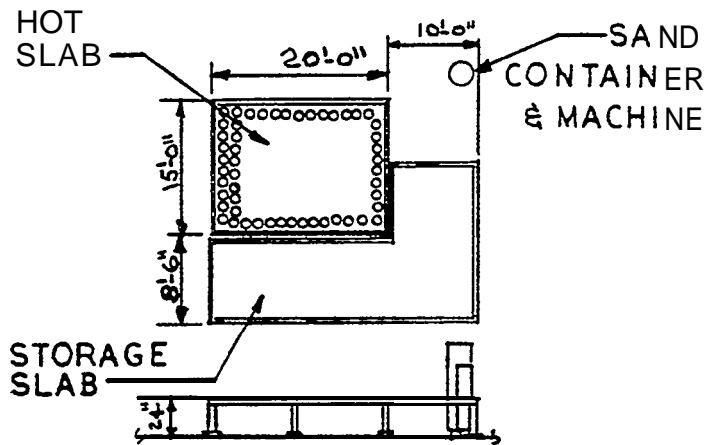
This machine is similar to that of 7-1A .

Number of Set  
 Applied Pipe and Flange: 8" - 12"  
 Nominal Size: 8" - 12"  
 Length of Pipe: 3' - 20'  
 Shape: Straight with/without flange  
 Operation Control: Same as 7-1A



12" N.C. Bender

- 4 Hot Bending System  
This system is available and used mostly due to the low volume of pipe size requiring bending.
- |               |   |
|---------------|---|
| Number of Set | One   |
| Nominal Size: | Over 6" Extra Heavy   |
| Length:       | 2'-20'  |
| Material:     | Carbon Steel, Stainless Steel, Copper, Copper-Nickel, Etc.  |
| Composition:  | Furnace or other heat source slab for securing pipe and making bend equipment for handling sand and pipe forming jigs and dies torches and radiant heat boxes and stress relieving equipment. |



*Hot Bending System*

- 8-1 Contouring Machine  
This machine provides the versatility of contour cutting the various alloys with simultaneous beveling.
- |  |   |
|--|---|
| Number of Set:                               | One   |
| Applied Pipe                                 |   |
| Material:                                    | Carbon Steel, Stainless Steel, etc.   |
| Diameter                                     | 2" -10"   |
| Thickness:                                   | .156" -.624"  |
| Length:                                      | 20'   |
| Composition:                                 |   |
| Power source:                                | Max. 500A (D.C. dropping characteristics)<br>Secondary load voltage: 200V or 400V |
| Fume exhaust device                          |   |
| Air compressor for plasma                    |   |
| Torch positioning device:                    | Manipulator, sensor, guider   |
| Consumable Parts:                            | Electrode 2-4 hours<br>Nozzle 1-3 hours   |
| Optional select standard gas cutting system. |   |

#### Operation:

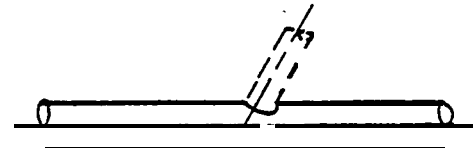
The pipe fed from conveyer by push button shall be set and cut via push button controls. This machine is typical of item 3-2.

- 9 Elbow and branch pipe assembly, welding system  
9-1 Semi-Automatic 40 deg. -60 deg. hole burning and welding machine.

Branch pipe piece is processed on contour cutting machines (3-2 and 3-4). Branch pipe is conveyed to branch pipe storage. Main body pipe is selected and positioned in 40 deg. -60 deg. hole burning machine. The machine automatically cuts the main pipe hole while calculating the contour with analogue control.

- |                 |   |
|-----------------|---|
| Applied Pipe:   | 2" - 24".   |
| Nominal Size:   | 2'-20"  |
| Length:         | 2'-20"  |
| Material:       | Carbon Steel, Alloy Steel, Stainless Steel, Etc.        |
| Cutting Method: | Plasma cutting with pipe rotation and torch movement    |
| Composition:    | Chuck equipment with cutting torch pipe support roller. |

"Function & Control  
Main Pipe Hole Cutting



Joint Angle 40 Deg. -60 Deg. -90 Deg. -150 Deg.  
Contour Computing Method: Analogue Control  
Beveling Control of Torch

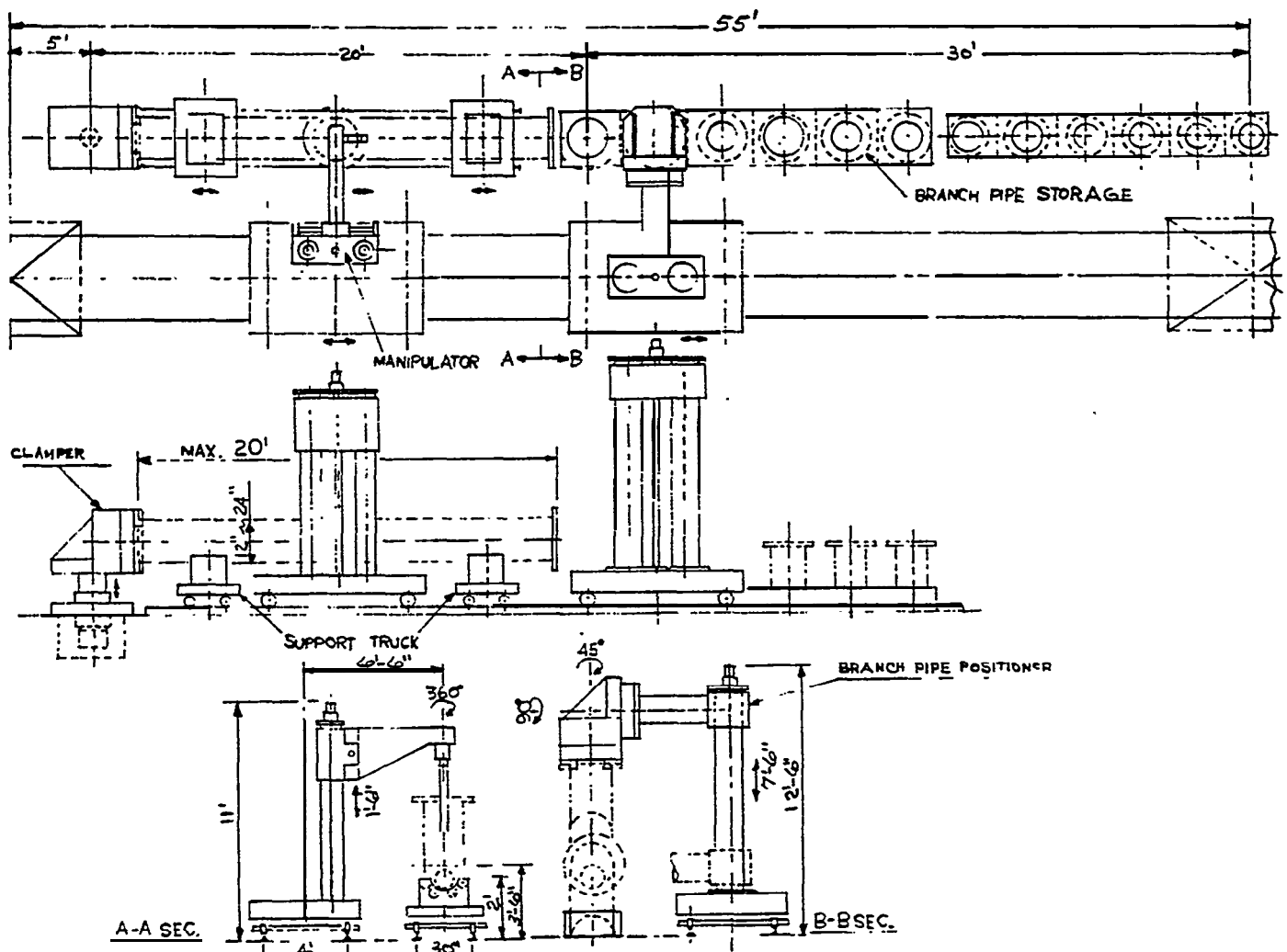
- (1) Constant Angle Beveling:  
Inclination angle of torch is constantly fixed.
- (2) Constant Point Beveling  
Torch is always aimed toward the intersecting point of main and branch pipe's center line.  
Setting Valve: By dial main pipe diameter. branch pipe diameter joint angle.

#### Hole Cutting Operation

Main pipe is set by push button control. After setting the required data and positioning the cutting torch is automatically accomplished.

#### Fitting and Welding Operation:

Branch pipe is positioned on the main pipe by means of branch pipe positioner by push button control; tack welding is manual; welding is manual.



*Semi automatic branch pipe assembling & welding machine*

## 9-2 High Elevated Elbow Welder 2" -12"

This device is used to semi-automatically fit and weld pipe to pipe and pipe to elbow.

Number of Set One

Applied Pipe, Elbow

Material: All materials

Diameter

Length: Max. 20'

Composition

Fixed pipe chuck with jack-up

Moveable elbow chuck with jack-up

Moveable support roller

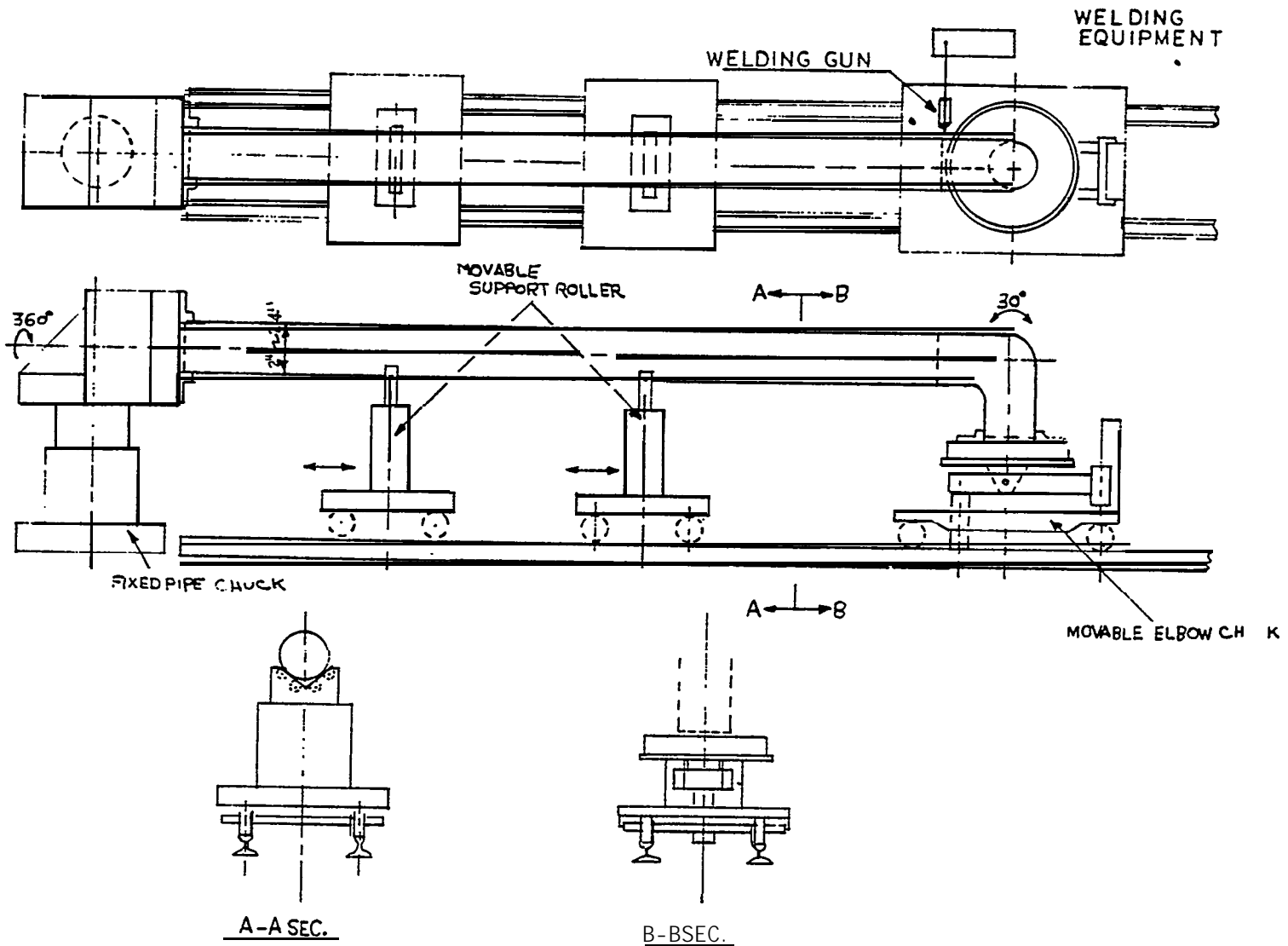
Operation-Rotator

Support rollers are moveable push button control

Pipe chuck and elbow chuck are operated by push button control

Operation-Welding

Tacking is manual; welding is semi-automatic submerged arc, manually positioning the welding gun to the groove. The welding process and rotating device is push button controlled and carried out automatically.



*Pipe rotator and elbow fitting device (2".24")*

9-3 Cypress Hole Cutting and Welder Branches (2" - 24") 90 Deg.

This machine is designed for automatically burning the hole and semi-automatically fitting and welding 90 Deg. branch pipe to main body pipe.

Number of Set: One

Applied Pipe Nominal Size: 2" -24"

Length of Main

Pipe: 2'-20'

Material: All

Composition:

Branch Storage Area

Chuck equipment with cutting torch

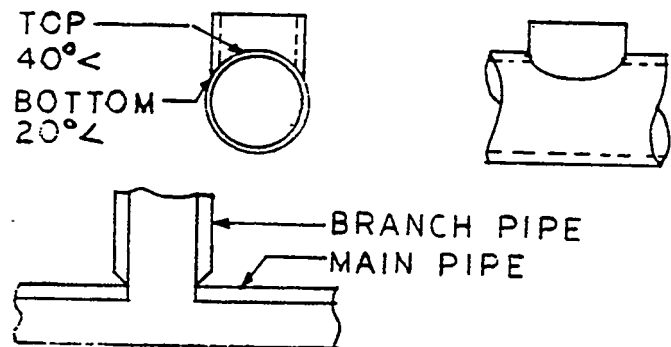
Pipe support

Chuck equipment with welding torch

Function and Control:

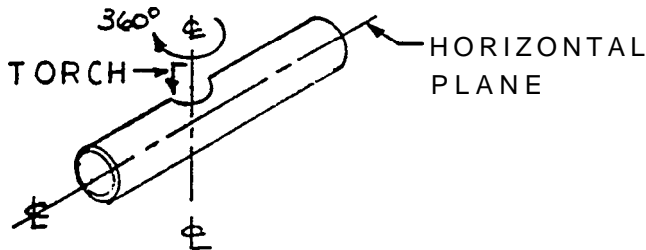
Branch pipe is cut on contouring machine (3-2)

Bevel is suitable for saddle on fitting, 40 deg. top. 20 deg. bottom.



*Saddle on branch positioned on main pipe.*

Main body pipe is selected and set in appropriate position in machine automatically by push button control. Cutting torch is set in appropriate position and hole cutting is anticipated and completed via push button control. Torch angle is maintained at 90 deg. to horizontal plane of main body pipe using plasma or gas cutting system.



Main body pipe is in fixed position, torch makes 360 deg. turn holding 90 deg. to horizontal plane following external shape of main body providing the contour cut. After the hole is cut in main body the branch pipe is selected from branch storage and set in saddle on position by means of the branch pipe manipulator via push button control.

Branch pipe is tacked to main body manually.

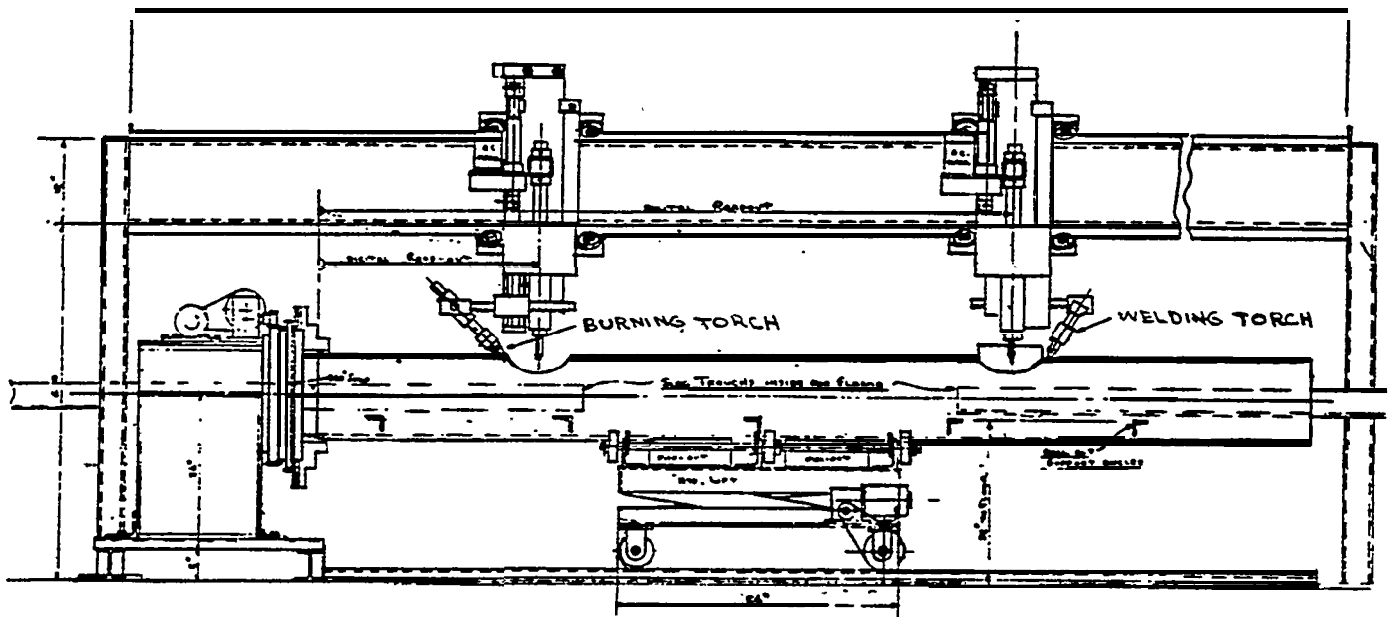
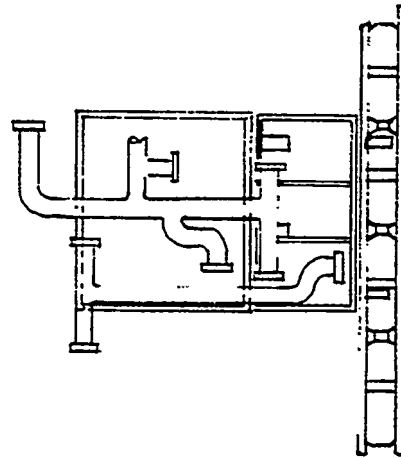
The welding head is set in position, torch is positioned to groove semi-automatically, weld is done automatically via push button controls..

#### 9-4 Final Assembly area

The final assembly area is equipped with jigs, fixtures, positioners and manipulators for fitting the sub-sub assemblies and sub-assembly pieces.

The sub-sub assemblies and sub-assemblies are fabricated at semi-automatic work station then conveyed to the final assembly area via push button select controls.

The main body pipe is set in fixture etc. manually. The main body, sub-assemblies and sub-sub assemblies are all pre fabricated. The fitting and tacking process is manual. Welding is accomplished semi-automatically when possible. Some pipe spools are of a configuration not conducive to automation. These items are manually welded.



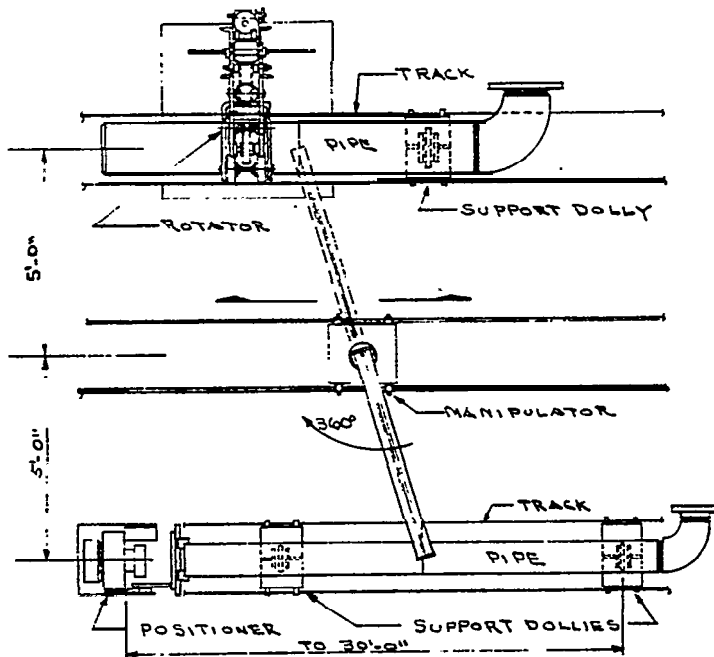
*Cypress hole cutting and welder-branches (2" - 14") 90°*

## 10 Various Types of Positioners, Manipulators and Welding Equipment

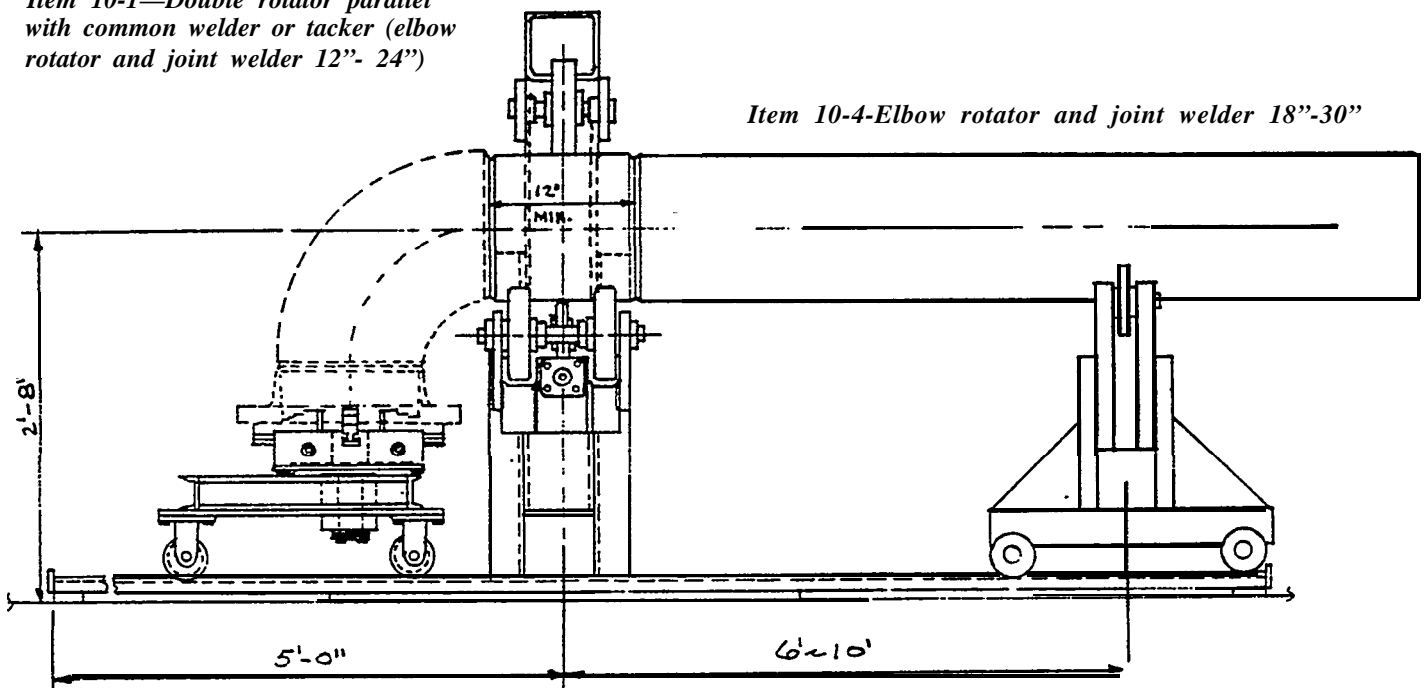
This equipment is placed at specific locations throughout the production line. Each item is fitted with kick-out for selecting and bringing the pipe to the machine via push button controls.

Each machine is designed for handling and manipulating the work piece to a position enabling the process to be automatically completed. The handling and manipulating is carried out by push button control.

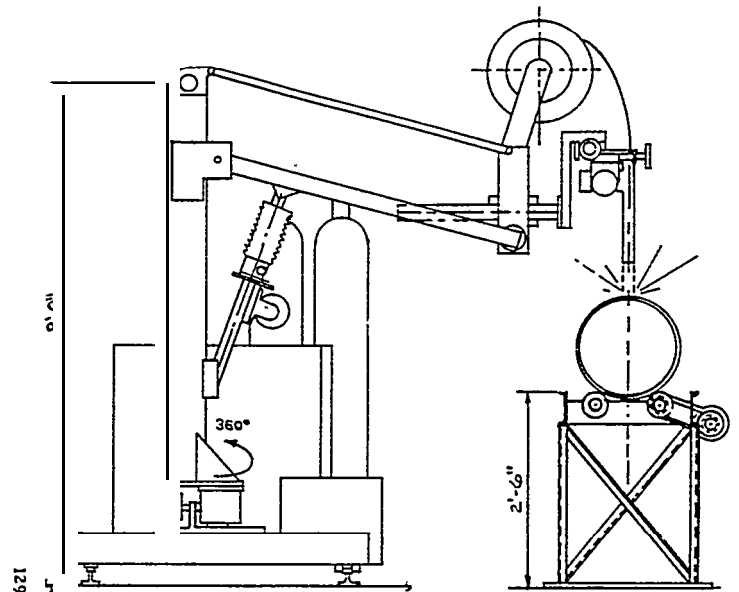
When the work piece is automatically set in the handling device, the process equipment (burning or welding) is positioned semi-automatically and the process is carried out automatically.



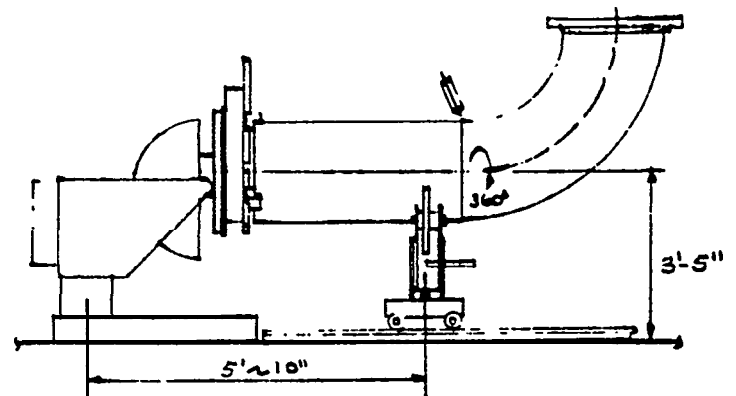
Item 10-1—Double rotator parallel with common welder or tacker (elbow rotator and joint welder 12"- 24")



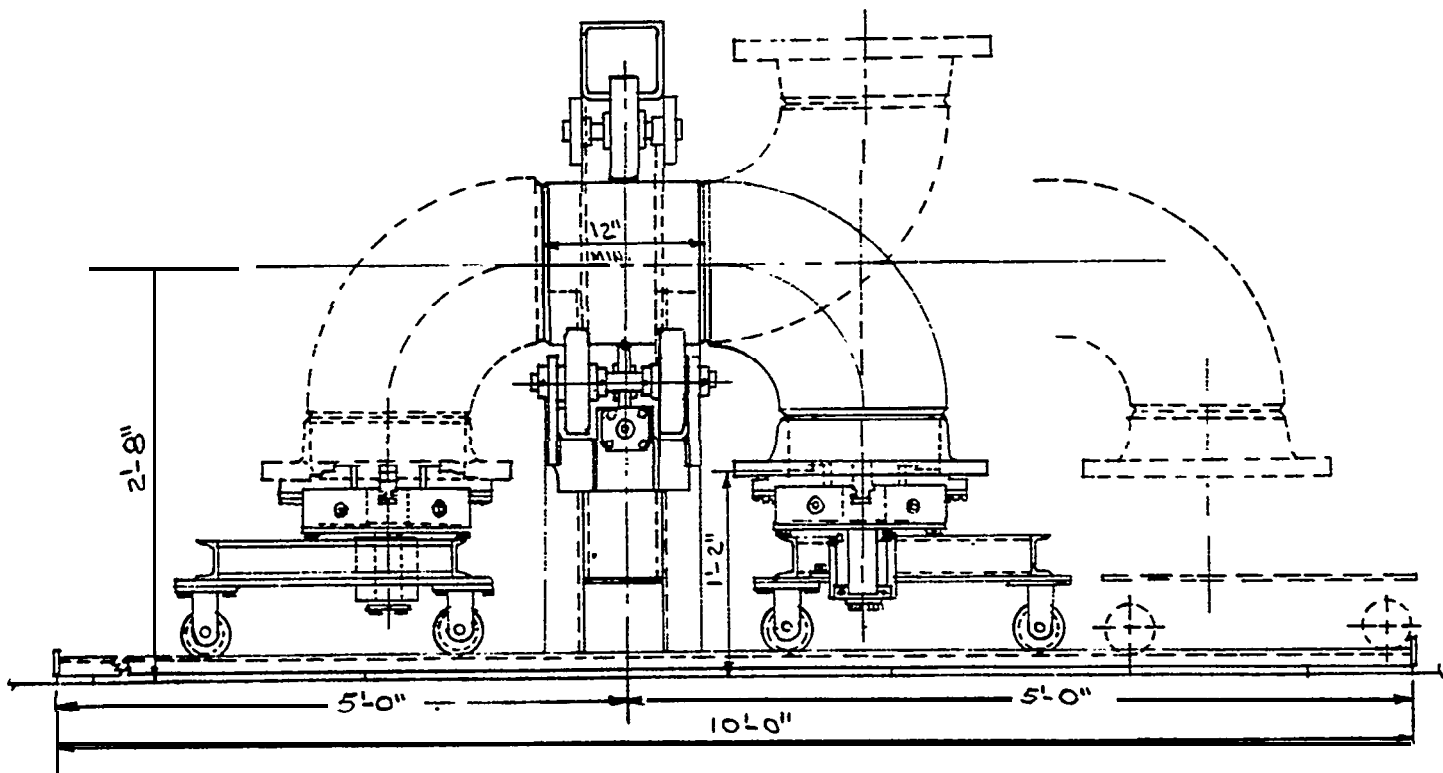
Item 10-4—Elbow rotator and joint welder 18"-30"



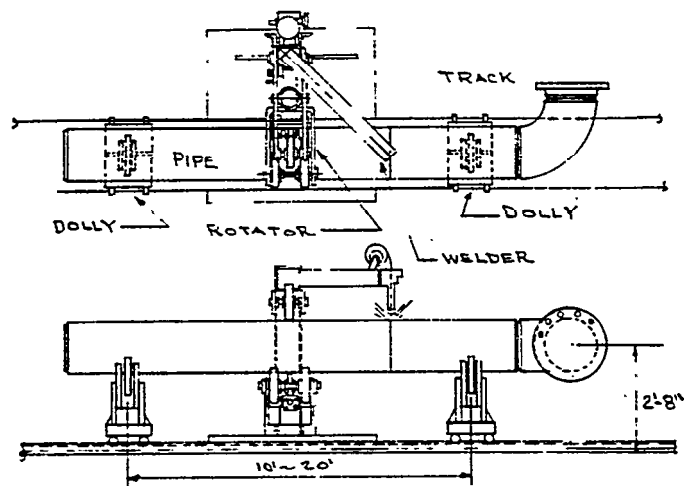
Item 10-2—Manipulator



Item 10-3—Elbow rotator and joint welder 18"- 30"



*Item 10-5—High boy rotator with 2-variable support dollies elbows 2'-12''*

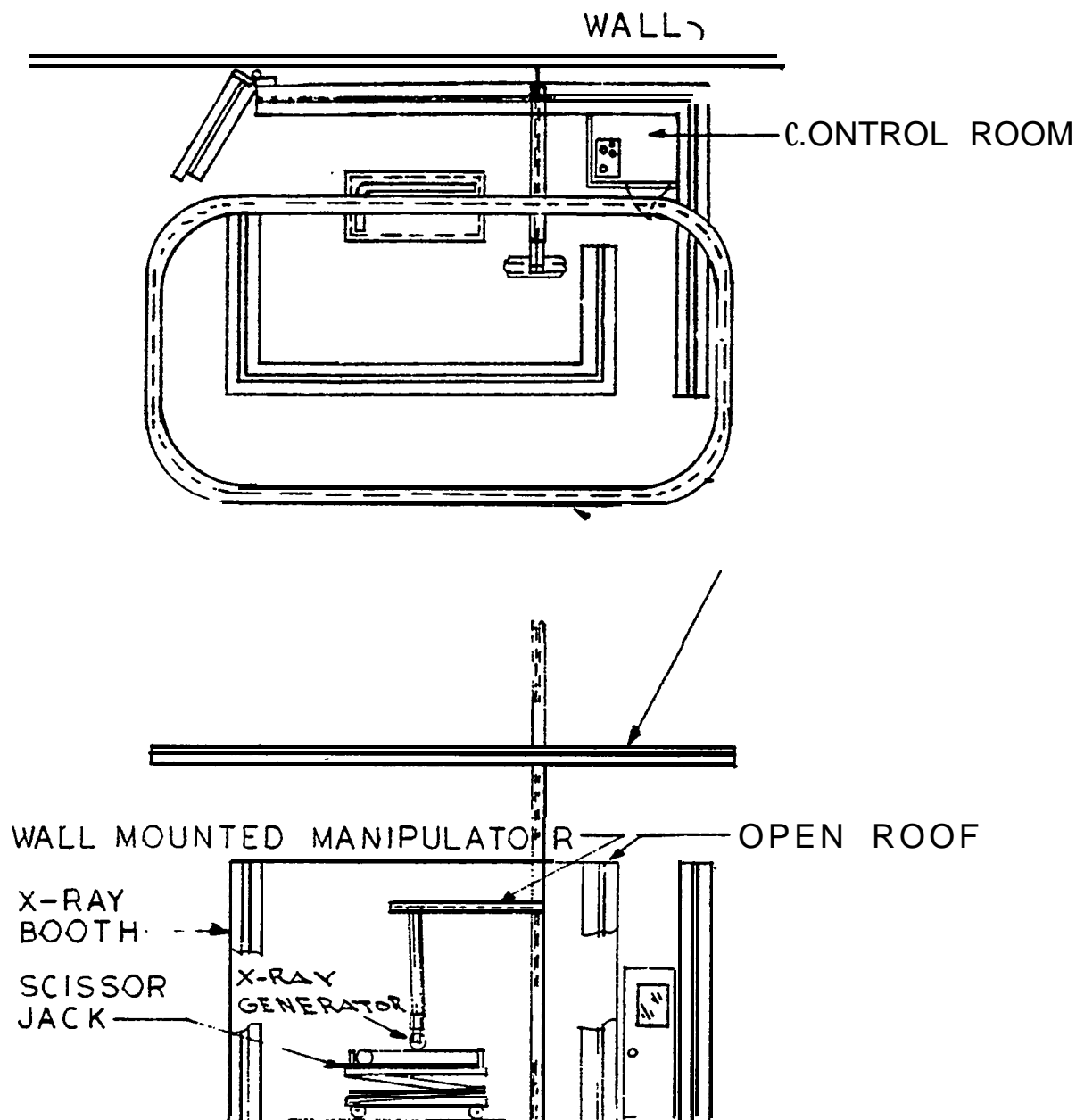


*Item 10-6—Pipe rotator and welder 2 double dollies*



- 11 X-Ray Facilities
- As the X-ray generator is fixed at the top of the magic-hand manipulator and as the film cover is magnet type, the setting work is quite easy on keeping pipe fixed.
- Number of Set: 2
- Applied Pipe
- |          |          |           |
|----------|----------|-----------|
|          | A        | B         |
| Diameter | 2" - 10" | 12" - 24" |
| Length   | Max. 24" | Max. 26"  |
- Method
- Double walls double image method 4"
  - Double walls single image method 4"
- Composition
- X-ray booth with lead and concrete walls
  - X-ray controller
  - X-ray generator and magic-hand manipulator
  - Overhead motorized chain conveyer

Function		
Exposure time	A	B
	2 min.	1 min.
Emission distance	2 feet	2 feet
Film density	2	2
Operation		
The most suitable condition with the least time film and generator setting work is manually done with the device.		
X-ray operation is done at the control room via push buttons and select switches.		



### 11-7 Motorized Scissor Jack Dolly

This is the equipment for transporting the finished pipe.

Number of set: Four (4)

Applied Pipe Shape: All shapes/straight, bent, flanged, branched

#### Function & Control

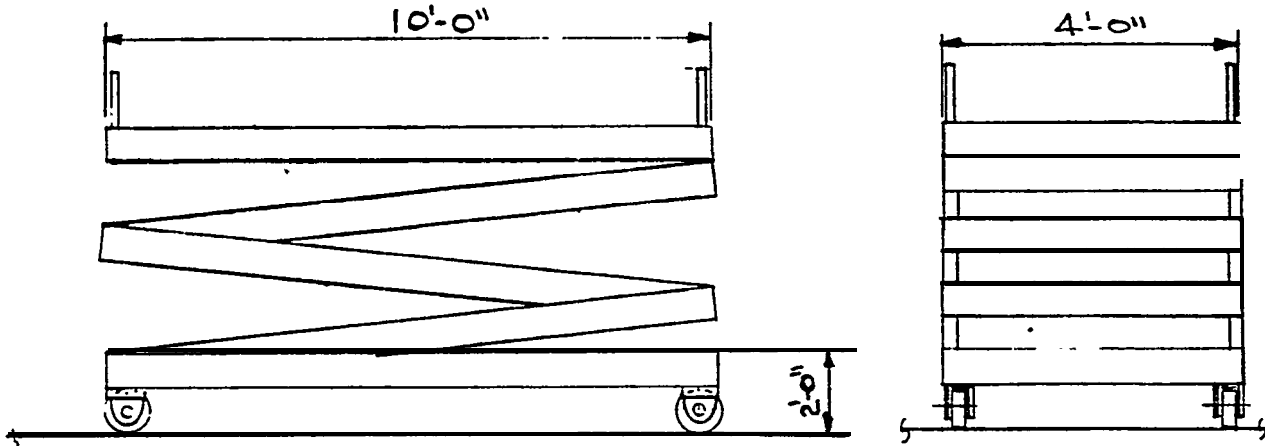
Loaded capacity: 2000#

Speed: 3' - 450'/min.

Drive: By motor

#### Operation

Loading and unloading of pipes are done by means of crane.



### 12 Pipe Handling System

#### 12-1 Roller Conveyor

This is the conveyor which is designed for feeding the raw material pipe.

Typical:

One is 10 feet in length from storage for raw material to shot blasting machine.

Applied Pipe Size: 1½" - 24"

Function & Control

Drive of the feed roller:

Chain drive through electric geared motor

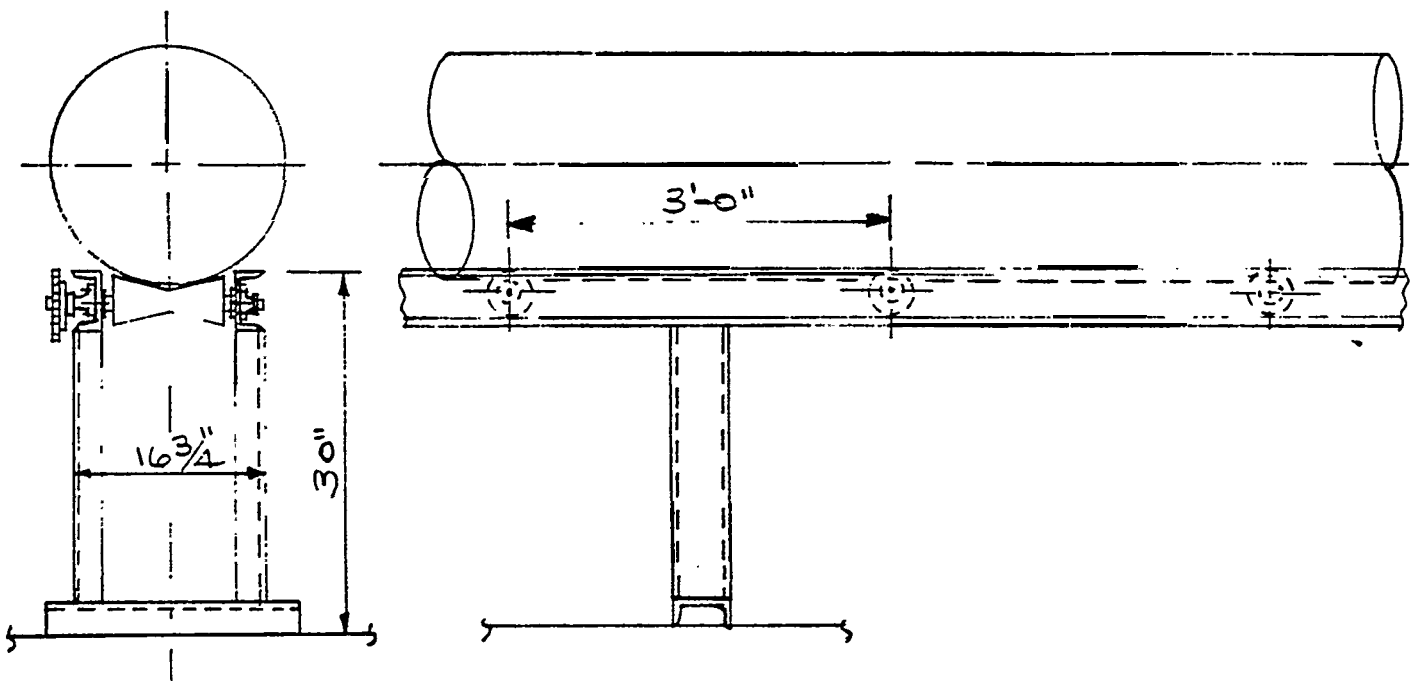
#### Speed of feed

variable: 50 - 150 feet/min

Control: In general, the conveyor is operated all the time. In case of detecting a pipe by the sensor or the pipe stopper, the conveyor is automatically stopped.

#### Operation

Push button control by operator

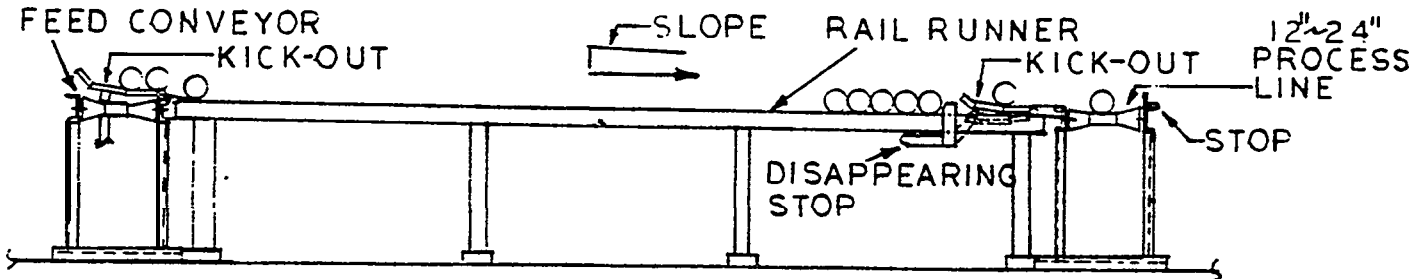


## 12-2 Traverser

This equipment is for traversing the pipe from the feed conveyor to the 12" -24" processing line.

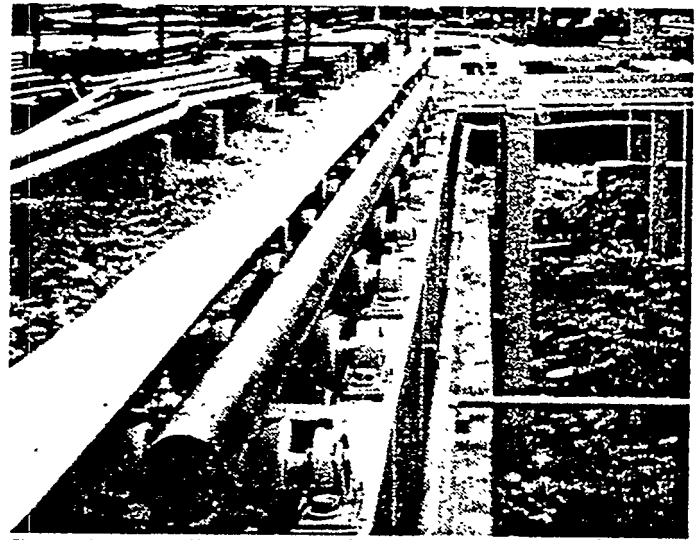
Typical  
Applied Pipe Size: 1½" - 24"  
Cross Over Rail runner  
Feeding Kick-out  
Travel Gravity

Stop position control: By pipe stop kick-out  
Operation Push button control by operator.

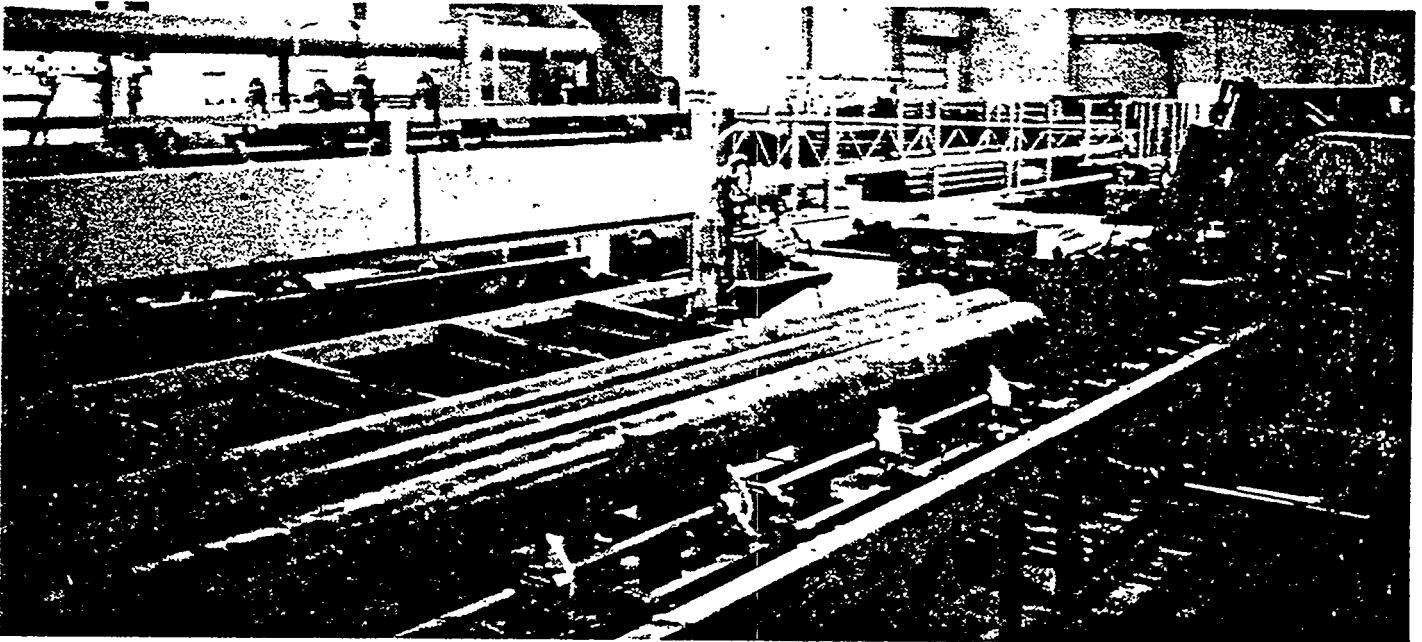


## 12-3 Pipe Kick Out for Conveyor

Typical  
Applied Pipe  
Nominal Size: 1½" -24"  
Length: 2'-20'  
Function & Control  
Drive: Pneumatic Cylinder  
Pipe Stop: Mechanical Detection by Limit Switch  
Control: Automatic Control when the pipe stop detects a pipe, the conveyor stops and the apparatus is energized to remove a pipe from the conveyor. In case shown in photograph, apparatus is operated by instruction, push button control at machine for pipe selection.



Typical pipe roller conveyor for transporting pipe from storage to the various work stations.



Three pipes in holding area held by typical conveyor pipe kick out ready for selection. Machine operator can push button; pipe moves to feed roller conveyor; roller conveyor moves pipe to machine for processing.

#### 12-4 Pipe Kick-Out for Transfer Tables

This device is for passing pipe from main feed roller conveyor to machine for processing or vice versa. Pipe piece will be of varying length and may have to be retrieved from slat or plate type conveyor.

Typical

Applied Pipe

Nominal Size: 1½" - 24"

Length: 2'-20"

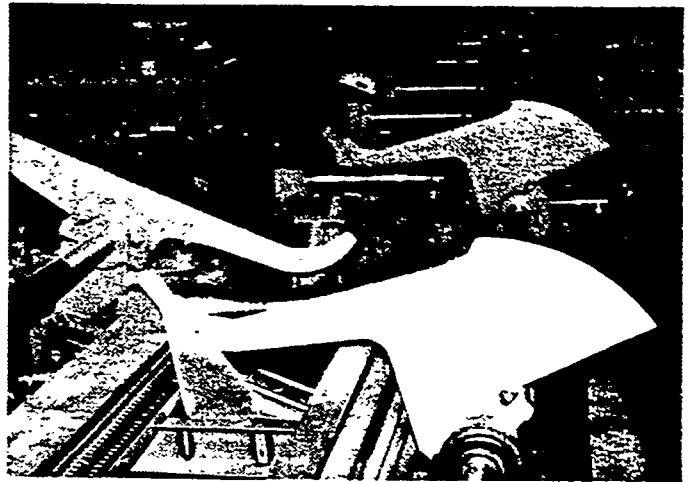
Shape: With or Without Flange

Function and Control

Drive: Pneumatic Cylinder

Control: In case of passing the pipe to the next work station the device is closed.

Operation: Push button control from the work station.



*Typical kick out device.*

#### 12-5 Chain Conveyor for 1½" -24" Completed Pipe or Pipe Being Processed

Typical

Applied Pipe

Nominal Size: 1½" - 24"

Length: 3'-20'

Shape: with or without flange

Function & Control

Drive:

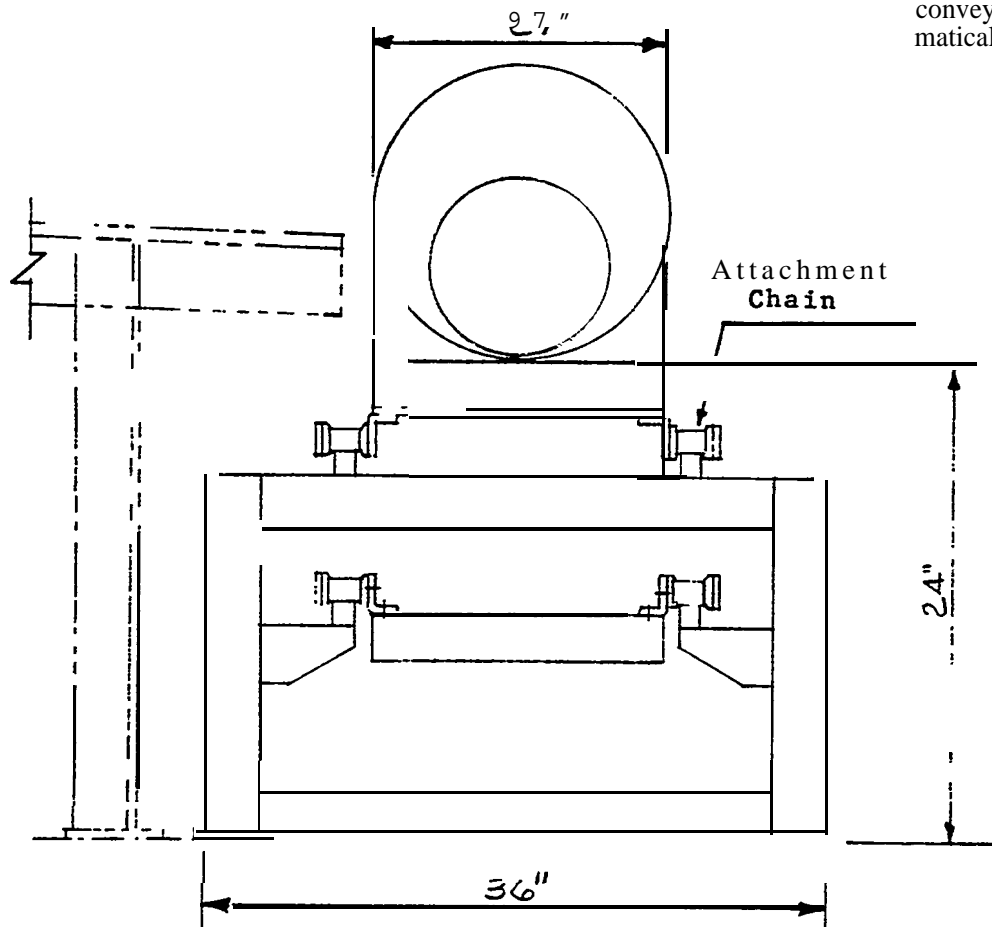
Speed:

Control:

Electric geared motor

Approx. 3'-50'

Automatic control. In general the conveyor is operated by push button control. When the pipe stopper detects pipe, the conveyor is automatically stopped.

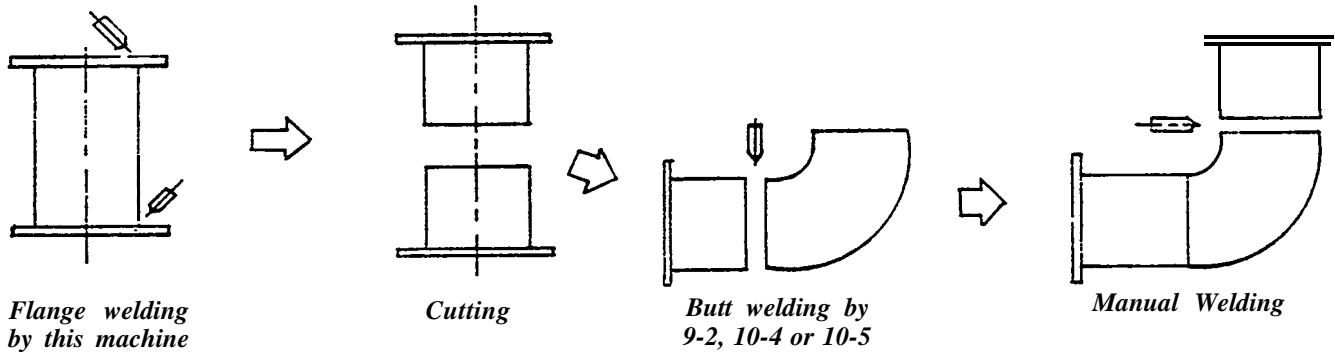


*Typical Section*

# 12-7 Automatic Flange Welding Machine for Short Pieces (12" - 24")

Very short pipe with flange, which would not be worked at the flange welding machine (5-1 or 5-2), are welded by this machine.

Number of Set: One  
Applied Pipe and Flange  
Material: Carbon Steel  
Diameter: 1/2"-24"  
Length: 3  
Method  
GMA automatic weld.



## Composition

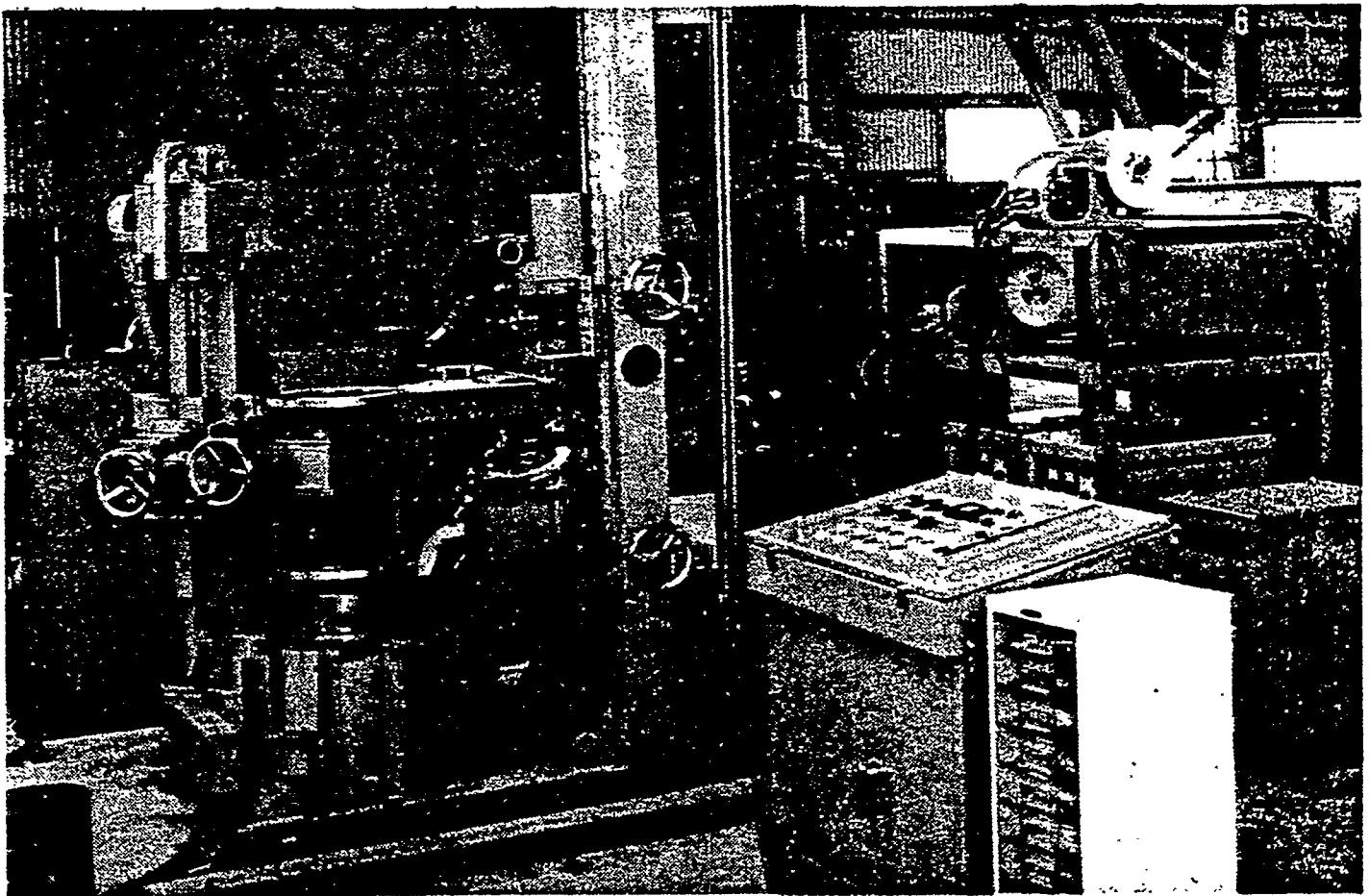
Torch positioning manipulator with guide sensor  
Pipe clamping and rotating device  
GMA Welder

## Operation

Electric current, voltage, welding speed and arc time are preset via select switches.

One side of pipe-elbow butt welding can be done semi-automatic elbow assembling & welding machine-( 104 or 10-5) and the other side of it shall be done manually after both flanges are welded by this machine.

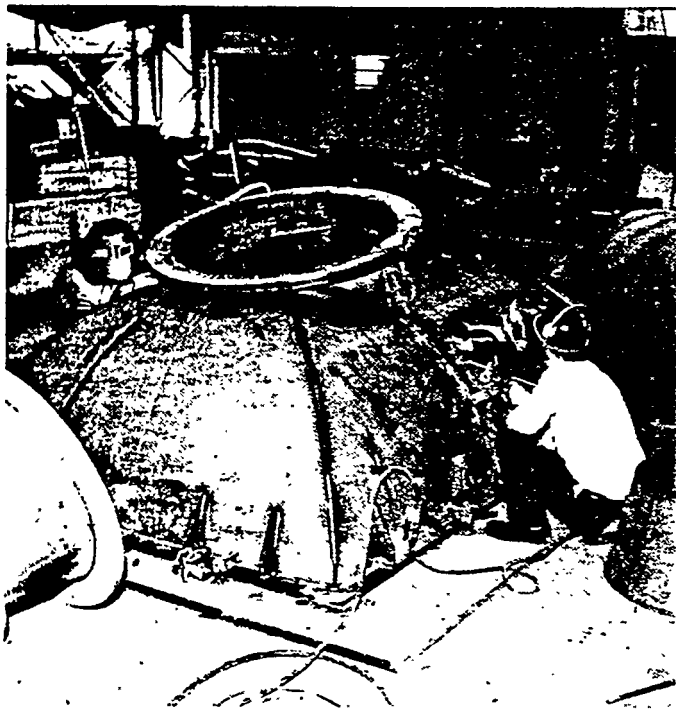
The torch positioning is done manually via push buttons and welding automatically by mechanical guide sensors.



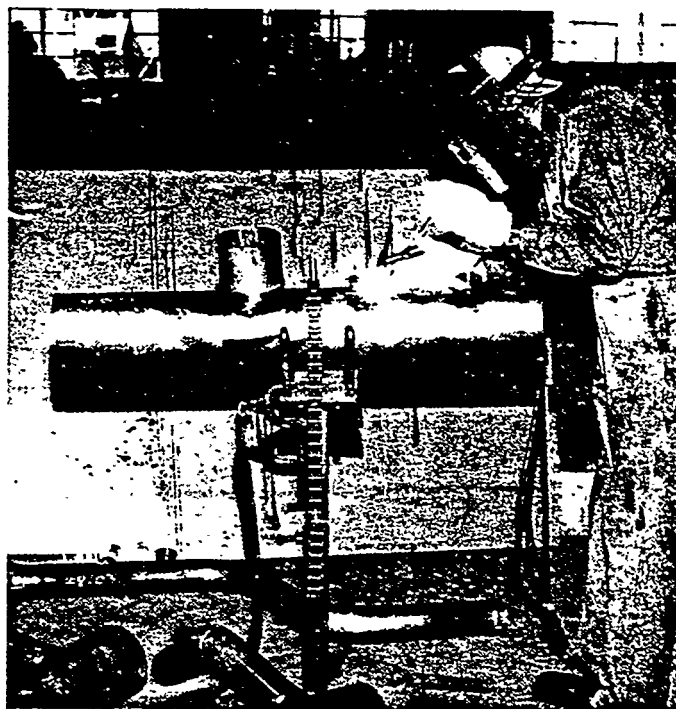
*Typical automatic flange welding machine for short pieces (12" - 24")*

13 Specialty Area  
 This area is comprised of machines, tools and handling equipment for processing items of configuration and volume not suitable for automation.  
 Number of Set: One  
 Method: The majority of this work is manual

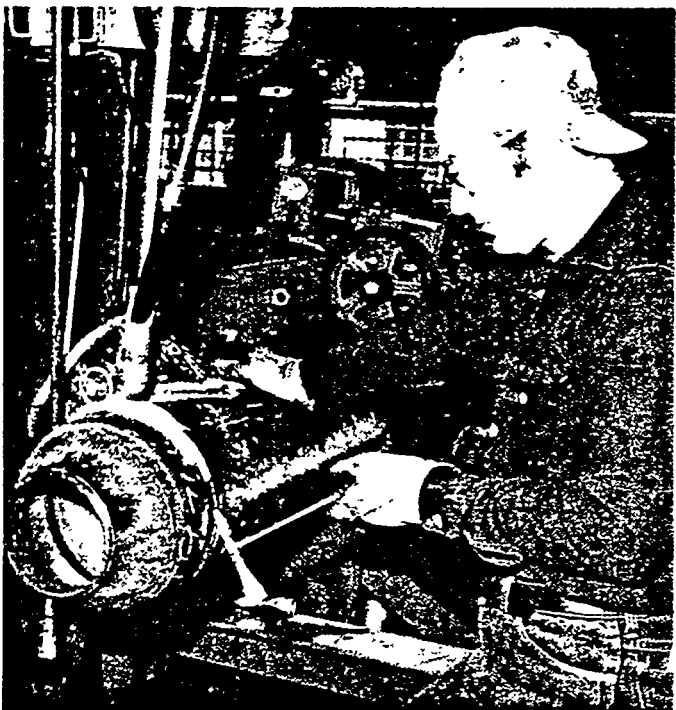
Composition: Pipe threading machine  
 $\frac{1}{8}$ " - 2"  
 Pipe threading machine  
 3" - 12"  
 Stone Saw  
 Band Saw  
 Various Welding Machines  
 Various Holding Jigs  
 Various Manipulators



*Manual fitting and welding of condenser head*



*Manual fitting and welding small part to main body pipe piece*



*Manual fitting semi-automatic welding reducer to pipe piece*



*Manual fitting and welding reducer to main pipe piece*



## **Section III**



## **Section III**

Computer Software System

### **INDEX**

- A. Summary
- B. General
- C. GPS (Graphic Piping System)
- D. Pipe Shop Production Control System
- E. Palletizing System
- F. Computer Software Outputs
- G. Computer Configuration to Accomplish  
Software Package

### A. Summary

This section is dedicated to computer software package information. The system outline, used as a sample, was developed by Mitsui Engineering and Shipbuilding Co. LTD..

There are several good software package systems presently on the market or under development. All of these systems have a common base utilizing somewhat different methods. The common base is the engineering part of the software system. The MAPS system includes three principal features which we consider essential to the operation of a pipe fabrication facility as previously outlined in Section II.

- Pipe Detail Drawings
- Pipe Shop Production Control System
- Palletizing System

A list of software suppliers is available in Section V of this document. Included in the list is the Newport News Shipbuilding and Dry Dock Company system which is currently under development. Also included is the Kockums Shipbuilding Company (System "Q" and "Steer Bear") system, which is excellent.

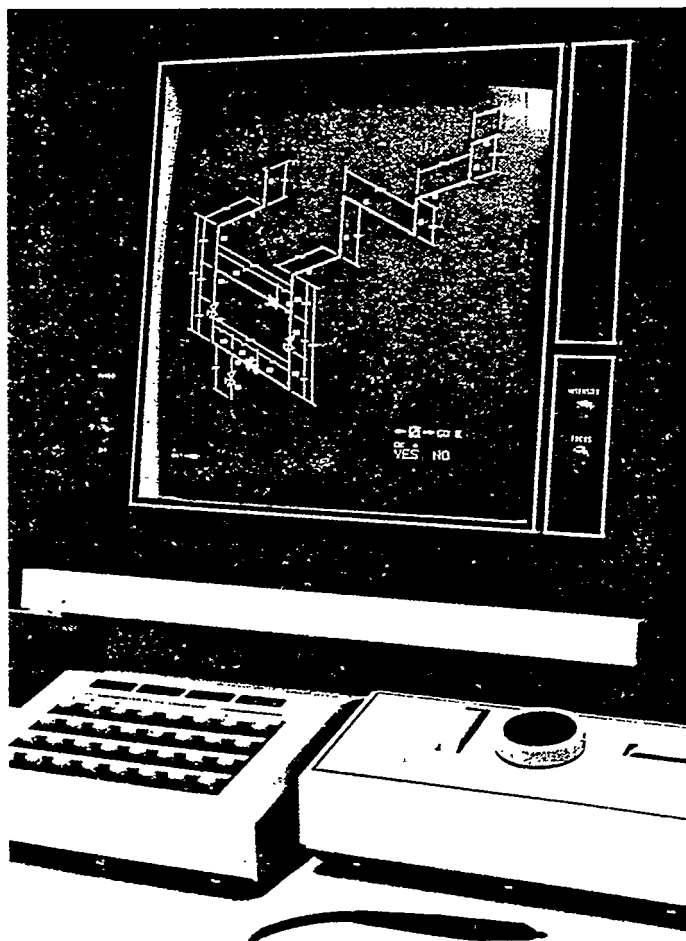


Fig. II-1 Photograph of graphic display MA CSGRAPH M-II-B used for GPS in the computer software package

### B. General

The computer software package developed by MES, now in successful operation at Mitsui's Chiba Works, is the system aided by computer to obtain information necessary for fabricating instruction of pipe pieces, material preparation, pipe shop production control and palletizing work.

The pipe fabrication shop and palletizing work cannot be operated smoothly and effectively without the support of this system.

For your new pipe shop project, we propose this computer software package as software to a semi-automatic pipe fabrication shop mentioned.

The proposed computer software package is composed of the following three (3) systems.

#### GPS (GRAPHIC PIPING SYSTEM)

From pipe arrangement drawings, necessary data are input by man-machine communication through the medium of graphic display coupled with exclusive mini-computer, which, in turn, calculates the shape and dimension of each pipe piece and furnishes the numerical information for fabrication of various kinds of pipe pieces.

The output of this system can be converted to the form best suited to the facilities and working method of the pipe shop, i.e., in the form of order card for NC equipments and in the form of numerical list for other equipments and manual work.

Furthermore, valve, piece, cock, bolt, nut, packing and other small attachments to pipe are also input together with pipe through graphic display.

These data are stored in the master file and are utilized by palletting system.

#### Pipe Shop Production Control System

Using the master file created by GPS as source data, host computer furnishes information required for the production control in the pipe shop such as scheduling of cutting date, cutting plan, material control and load balance.

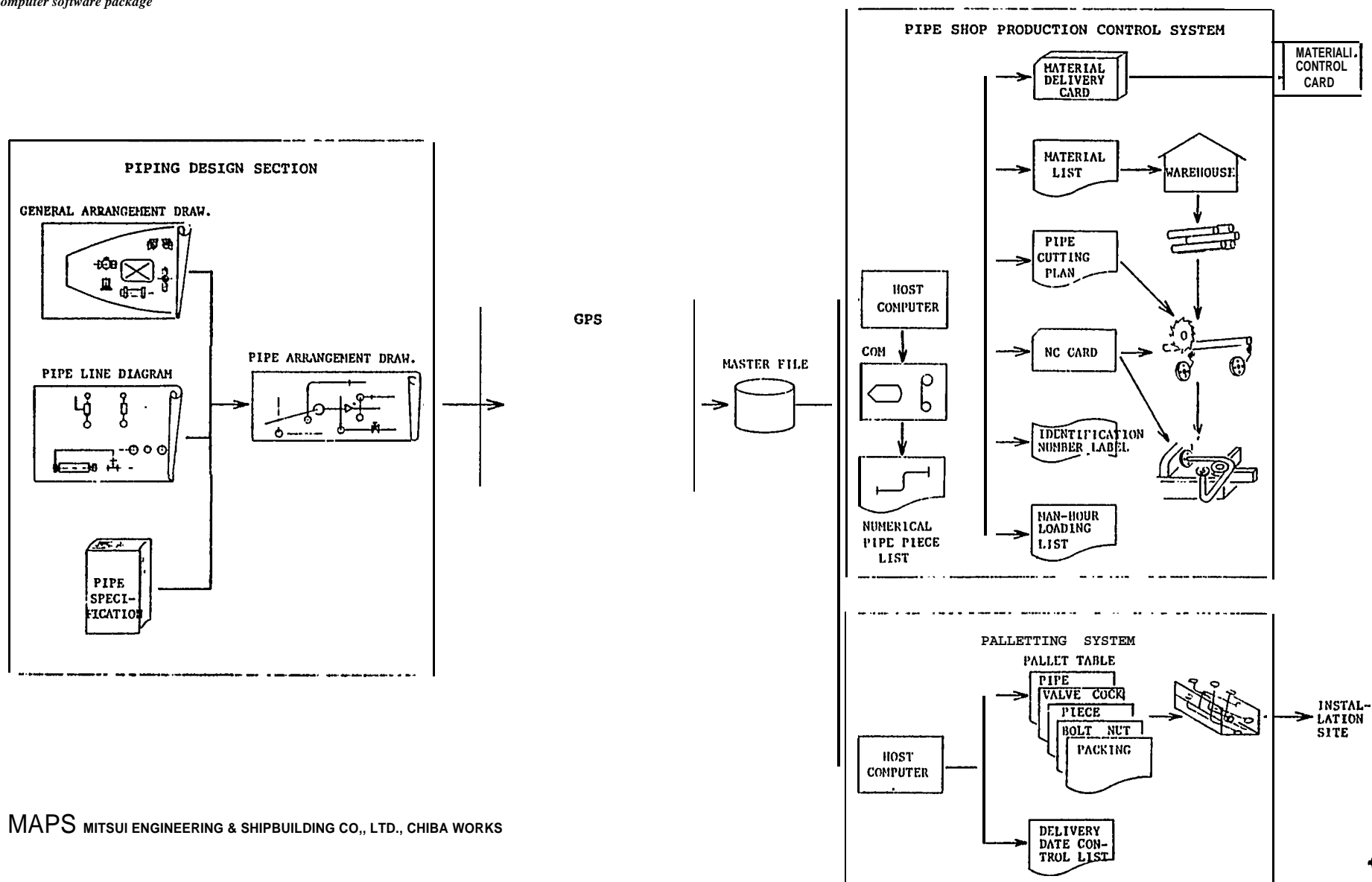
#### Palletting System

For smooth progress of outfitting work, it becomes necessary to timely collect and deliver outfitting materials such as pipes, valves, cocks, pieces, bolts, nuts, packing, etc. to installation site. For the sake of fulfillment of this necessity, we developed a material flow control system called "Palletting System."

In GPS, from detail drawings, necessary information for palletting is input and filed in the master file. They are edited by host computer and timely furnished to the pre-fabrication shop, materials purchasing department, materials management department and transportation control center, converting to the order forms met with requirement of each department.

**MAPS** MITSUI ENGINEERING & SHIPBUILDING CO., LTD., CHIBA WORKS

Fig. 11-2 General flow chart of the proposed computer software package



MAPS MITSUI ENGINEERING & SHIPBUILDING CO., LTD., CHIBA WORKS

### C. GPS (GRAPHIC PIPING SYSTEM)

For this system, mini-computer with graphic display processor is provided. (Refer to computer configuration in chapter 6.)

As one of the most effective methods to assist the designer in feeding data into computer, the graphic display coupled with exclusive mini-computer is used instead of big computer. In this system, the designer can give data to computer by man-machine communication through the medium of graphic display, light-pen and keyboard.

Therefore, filling in data sheets, card punching and verification can be eliminated.

The designer can get quick response from computer because of realtime interaction, and can easily modify the data on the spot.

This system is considered one of the latest practical application computer aided design system.

Process flow of this system is as follows;

At first, piping route is created on the graphic display screen from pipe arrangement drawing. On the other hand, piping specifications such as material, diameter, working pressure, working temperature, type of joints, coating, treatment, testing, etc. are coded for each pipe line from pipe specifications and filed by host computer as Pipe Line File.

The shipyards standards of fitting parts such as dimension, weight, cost code, etc. and working standards are also filed as Item Data File and Working Standard File, respectively.

Matching these data in the mini-computer, all informa-

tion necessary for pipe fabrication are calculated and stored in the master file, which are used as source data of the subsequent two systems; Pipe shop production control system and Palletting system.

Flow chart of procedure to feed data through graphic display is shown in Fig. II-3.

Numerical expression of pipe piece

In this software, not only graphic representation but also numerical expression is used to show the shape of pipe pieces.

In general, three dimensional shaped pipe shall be analyzed into straight length, girth length in bending corner, bending angle in plan and rotating angle in space, for instance, in Fig. II-4.

Computer analyzes the piping route on the graphic display screen into the above components, and they are arranged according to pipe fabrication procedure. Example of this arrangement is shown in Fig. II-5. Since information is given to workers in numerical expression as shown in the example, workers can easily perform their job such as marking, cutting, bending, assembling, etc. without any judgement, experience or good perception.

The relation between numerical expression and pipe fabrication procedure is shown in Fig. II-6. The bending process for any complicated shaped pipe with bender can be divided into three simple components of motion, feeding of pipe, rotating pipe, and bending pipe.

Therefore, so far as pipe processing is followed with numerical indication which consists of the above simple components, workers can easily perform their job without any comparison with graphic drawings.

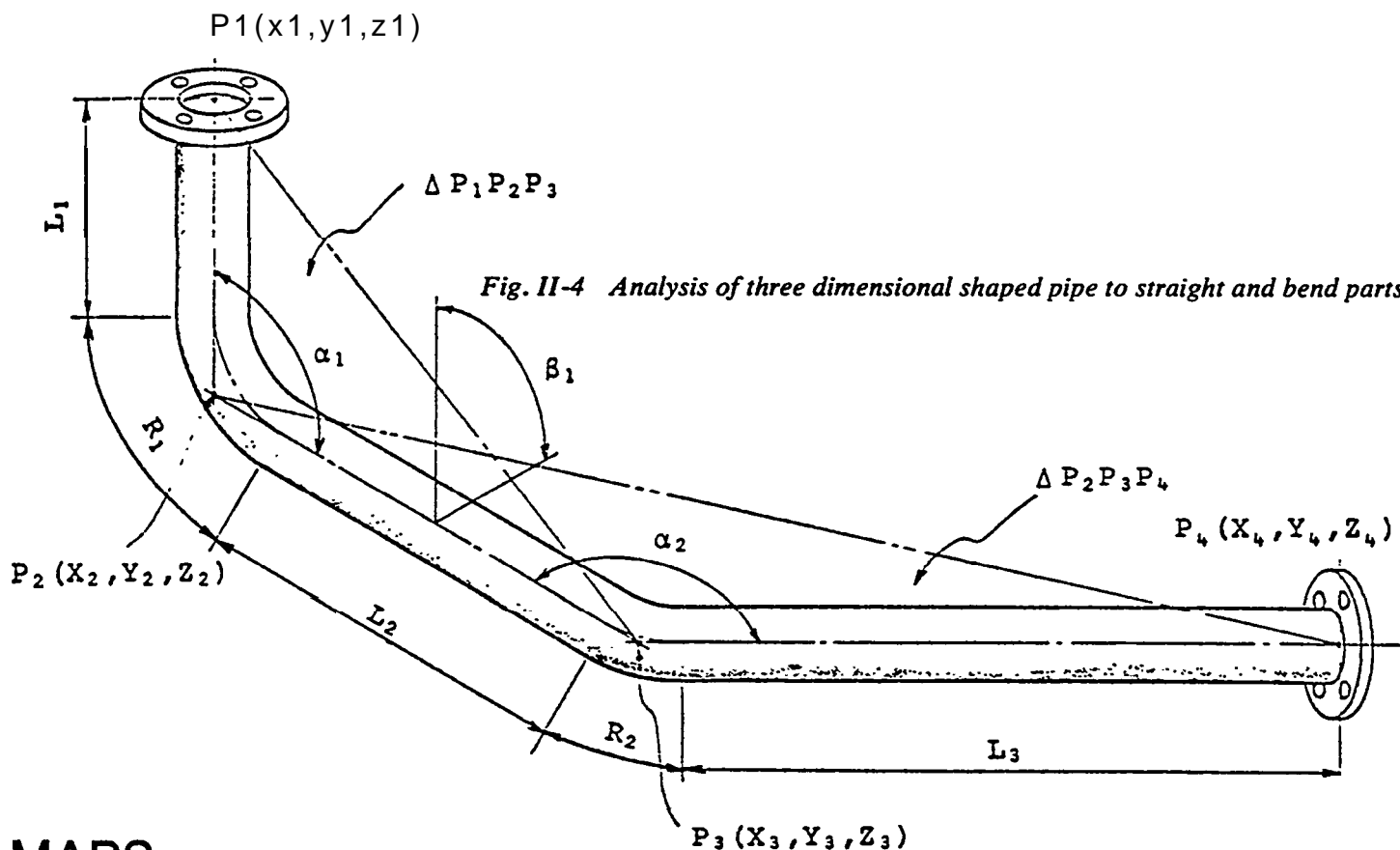
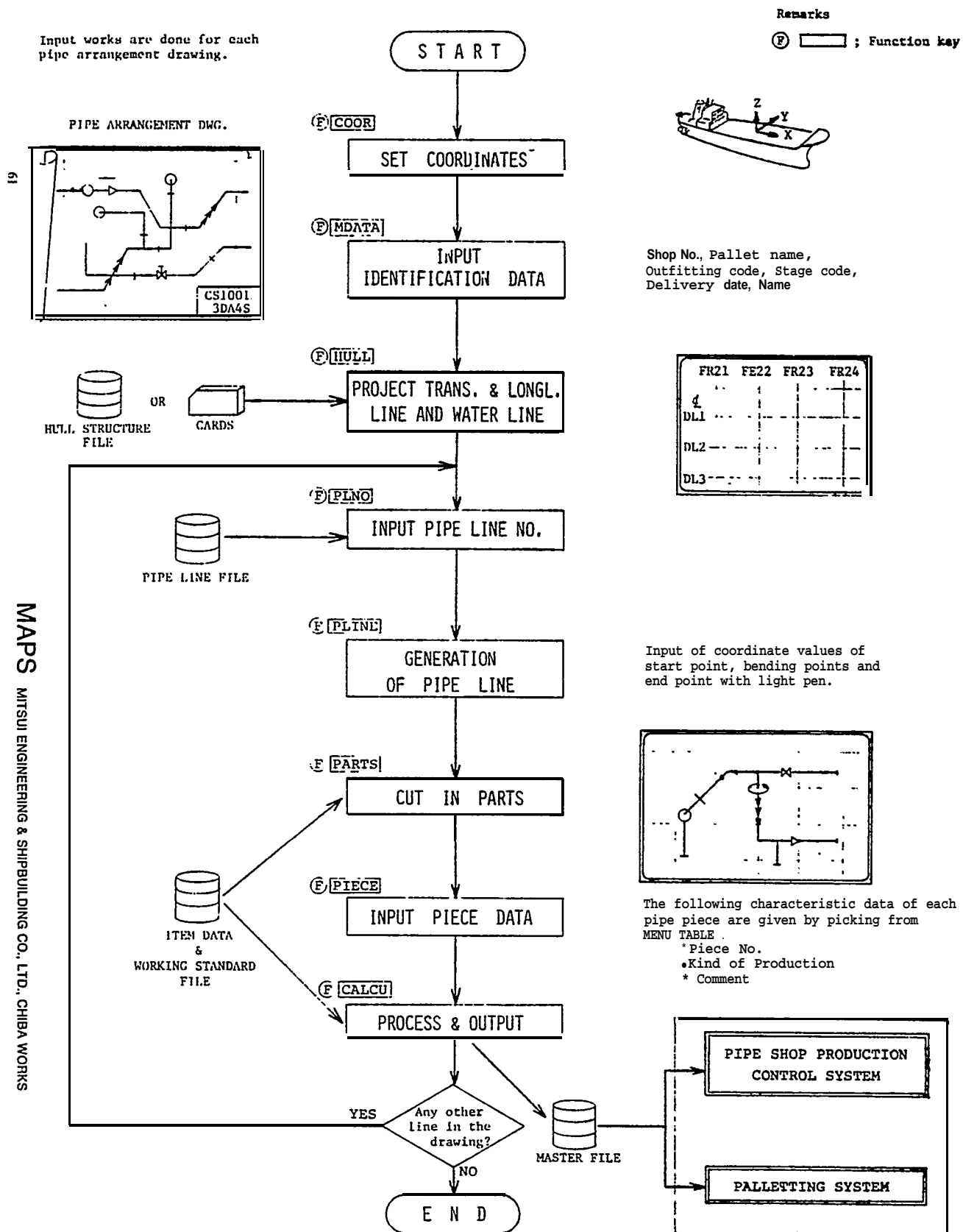


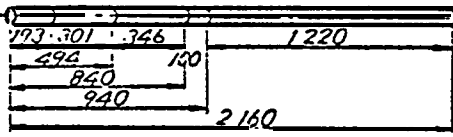
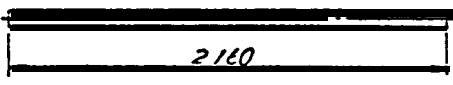
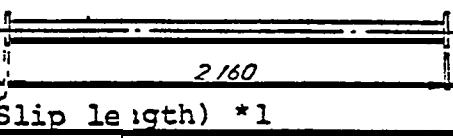
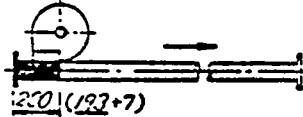
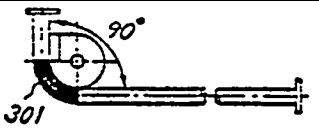
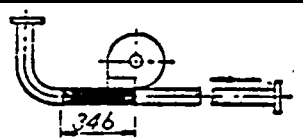
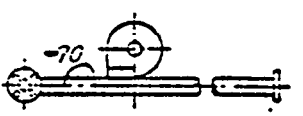
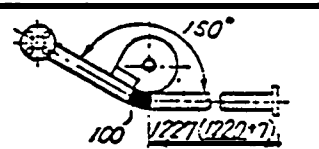

Fig. II-4 Analysis of three dimensional shaped pipe to straight and bend parts.

	1st straight ( length )	1st girth ( length )	2nd straight ( length )	2nd girth ( length )	3rd straight ( length )
	$L_1$	$R_1$	$L_2$	$R_2$	$L_3$
	[193]	[301]	[346]	[100]	[1220]
(Total length)	[193]	[494]	[840]	[940]	[2160]
		[90]	[90]	[150]	
		$\alpha_1$	$\beta_1$	$\alpha_2$	
		(1st bending angle)	(Intersecting angle between 1st & 2nd plane)	(2nd bending angle)	

Fig. 11-5 Numerical expression arranged according to pipe fabrication procedure

Fig. 11-3 Flow chart procedure to feed data through graphic display



	OPERATION SEQUENCE	EXPRESSION ON PART PLAN
MARKING		193 301 346 100 1220 193 494 840 940 2160 90 (90)150
CUTTING		193 301 346 100 1220 193 494 840 940 2160 90 (90)150
FLANGE FITTING AND WELDING		193 301 346 100 1220 193 494 840 940 2160 90 (90)150
BEND	FEED 	193 301 346 100 1220 193 494 840 940 2160 90 (90)150
	OBEND 	193 301 346 100 1220 193 494 840 940 2160 90 (90)150
	OFEEED 	193 301 346 100 1220 194 494 840 940 2160 90 (90)150
	ROTATE 	193 301 346 100 1220 193 494 840 940 2160 90 (90)150
	BEND 	193 301 346 100 1220 193 494 840 940 2160 90 (90)150
FINISHED FORM		—

NOTE:\*

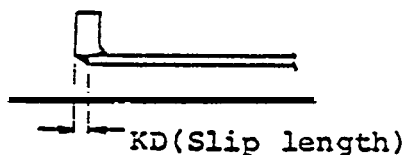


Fig. II-6 Relation between numerical expression and pipe fabrication procedure

#### D. Pipe Shop Reduction Control System

For the production control of pipe shop, scheduling program and cutting plan output program are provided.

Fig. II-7 shows its flow chart.

The master file, processed and filed by GPS, is used as the source data for the two programs above. This system is run under the host computer.

The process flow of the scheduling program is as follows;

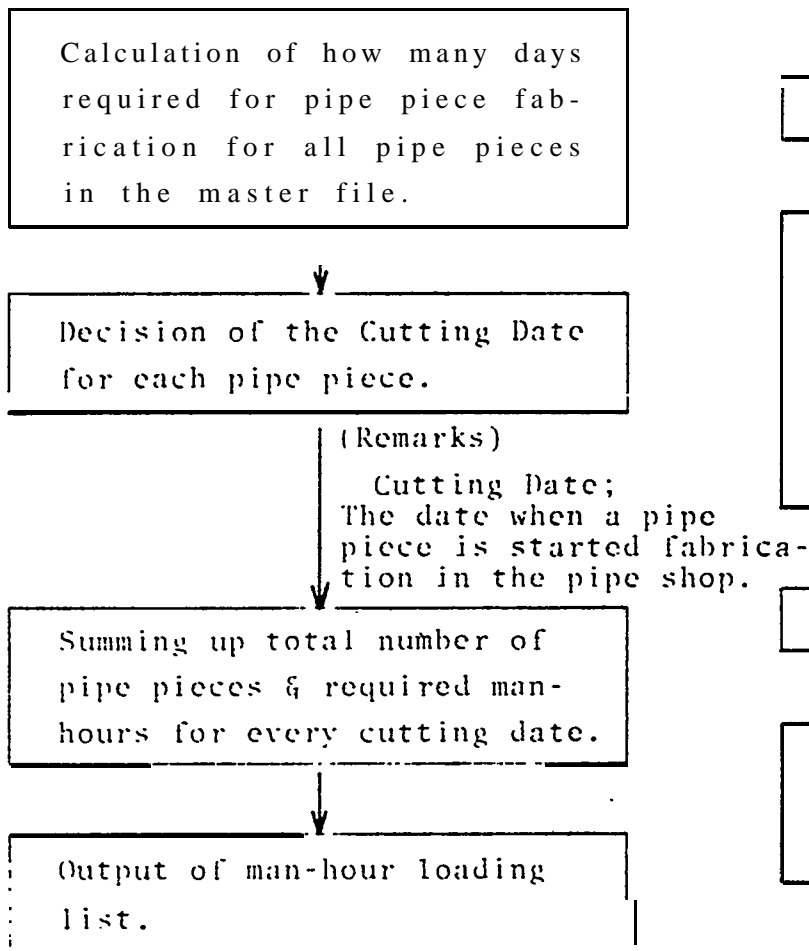


Fig. II-8 & 9

The process flow of the cutting plan output program is as follows;

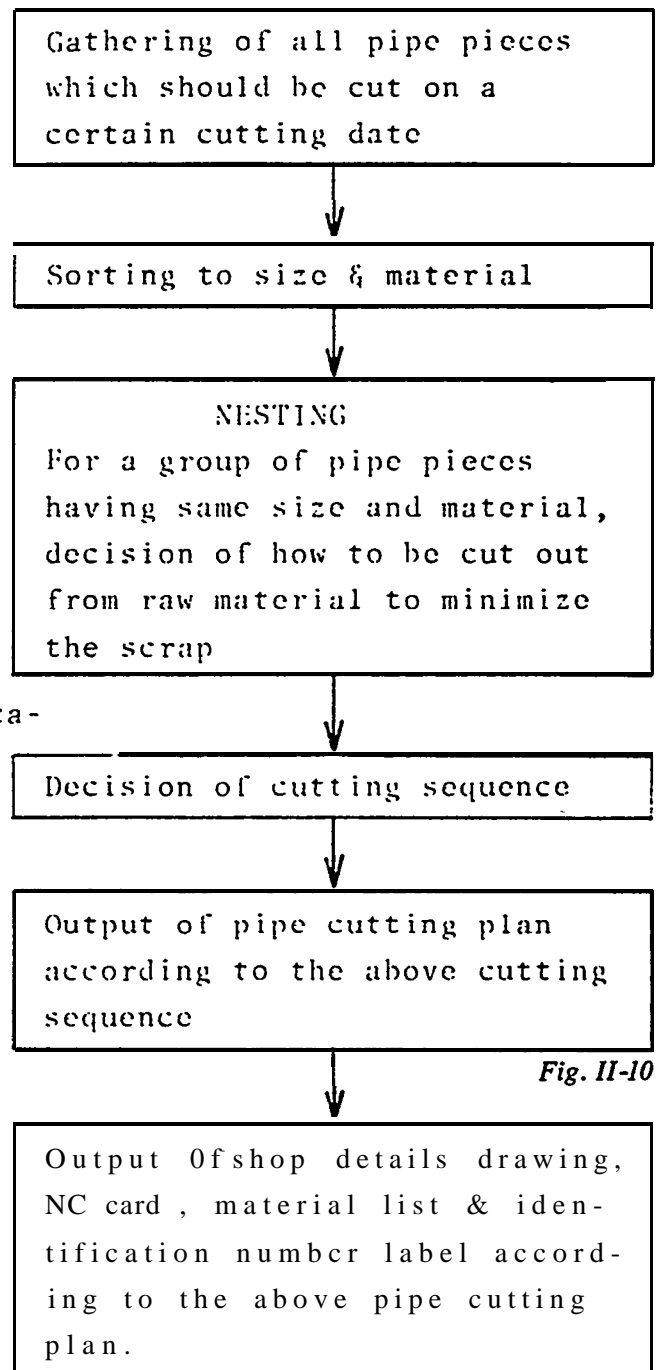


Fig. II-10

Fig. II-11, 12, 13 & 14



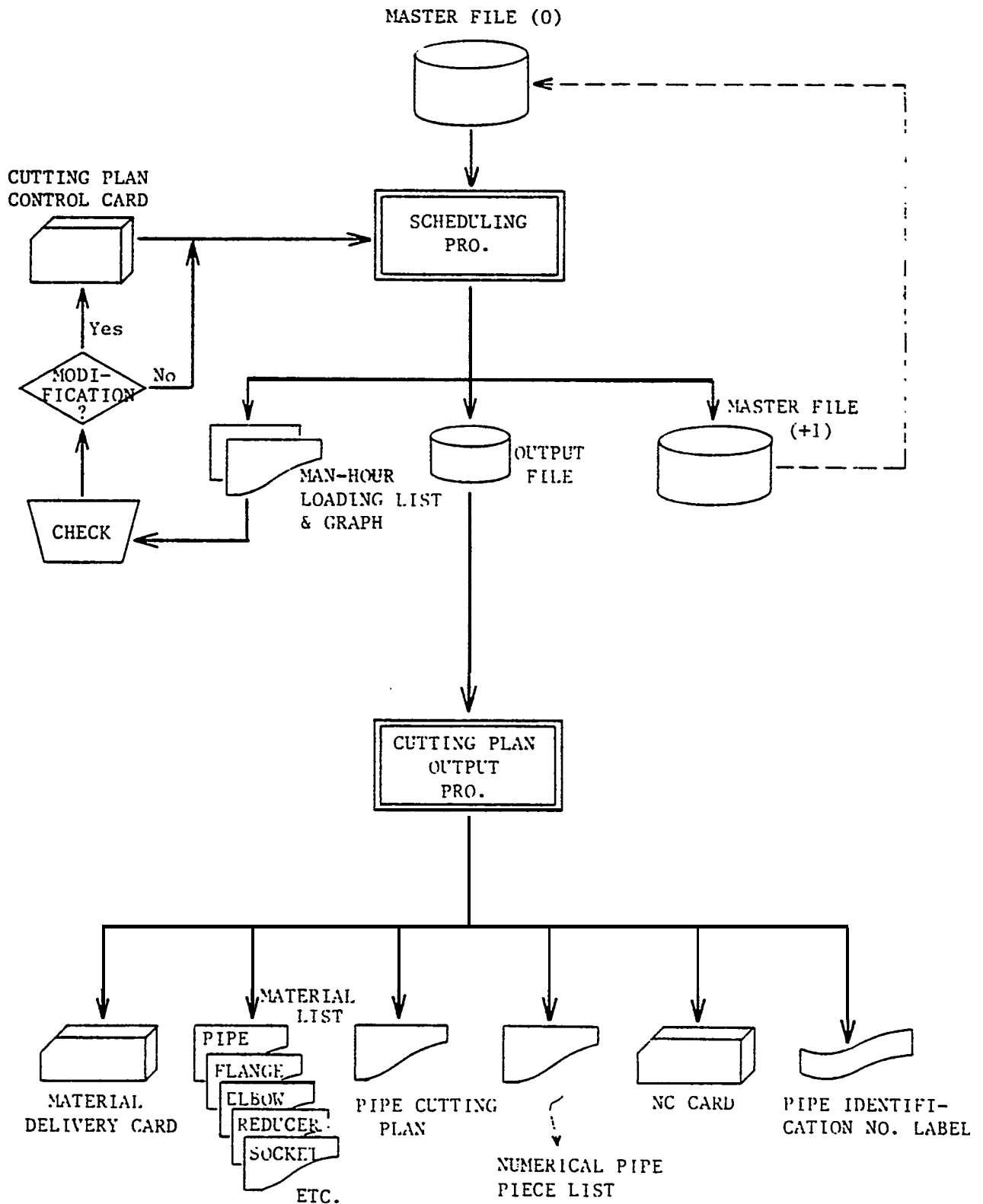


Fig. II-7 Flow chart of pipe shop production control system

## E. Palletizing System

For smooth and effective progress of outfitting work, complete and timely supply of outfitting materials to installation site is required.

For this purpose, the new concept “Pallet Outfitting System” was introduced to the field of outfitting work. That is; The whole outfitting work of one (1) ship is divided into many working units by working place and time, and then these small working units are completed in an appropriate order under necessary information for every unit. One (1) working unit has its own pallet name and delivery date. All materials belonging to one (1) pallet name must be collected by its delivery date, independent of kinds of materials.

This material preparation work is carried out with the support of Palletting System which supplies necessary information for material collection with the aid of computer.

Using the master file created by GPS as source data, host computer outputs pallet tables for each kind of materials, such as pipes, valves, pieces, cocks, bolts, nuts, packing, etc.

The pallet table affords items necessary for palleting as shown below.

- Job order (ship number)
- Pallet name
- Delivery date, Fitting date
- List number, Order number, Drawing number
- Kind of type
- Article code
- Quantity, Weight

Owing to the development of Palletting System, all outfitting materials are completely palletized without any missing parts and are supplied to installation site just in time, so that outfitting work can be done smoothly.

F. Computer Software Outputs

SYSTEM	OUTPUTS	EXPLANATION	SAMPLE;
1111: SHOP PRODUCTION CONTROL SYSTEM	MAN-HOUR LOADING LIST & GRAPH	For every cutting date, total number of pipe pieces and required man-hours are shown. This indicates future working load in the pipe shop. In order to keep good load balance, this man-hour loading can be modified by giving "Cutting Plan Control card" to computer.	Fig. 11-8 G Fig. 11-9)
	PIPE CUTTING	This list is output every working day. All pipes to be cut on the day are printed out in this list according to cutting sequence decided by computer to minimize the scrap pipe and the time for exchanging machine tools.	Fig. 11-10
	MATERIAL LIST	According to "Pipe Cutting Plan", all materials used for fabrication of pipe pieces, such as pipes, flanges, elbows, reducers, sleeves, sockets, etc. are summed up classifying to cost accounting code, size, material, type, etc.	Fig. 11-11 & Fig. 11-12
	NC CARDS	Two kinds of numerical control cards (NC cards) are used as instructions to numerical control machines. These cards are the outputs from computer in the same order as cutting sequence shown in "Pipe Cutting Plan".	Fig. 11-13

SYSTEM	OUTPUTS	EXPLANATION	SAMPLE
PIPE SHOP PRODUCTION CONTROL SYSTEM	IDENTIFICATION NUMBER LABEL	After a pipe piece is cut, this label, which is also the output, from computer, is put on it for identification such as ship number, pallet name, serial number, fabrication line and path, kind of treatment, etc.	Fig. I-14
	NUMERICAL PIPE PIECE LIST WITH GRAPHIC REPRESENTATION	This list, which is output by COM (Computer Output Micro-film), is used for numerical instructions to workers, i.e., shop details containing all the necessary alpha-numeric information for cutting, fitting, bending, welding, painting, testing and identification. This is provided for every pipe piece.	Fig. II-15
	PALLET TABLE	This table is used for collecting and delivering all articles by each pallet name. It contains palletting information such as delivery date, list number, order number, size, type, material, quantity, weight, etc.	Fig. II-16
PALLET NG SYSTEM	DELIVERY DATE CONTROL LIST	This list is used for giving appropriate delivery date, in case that material purchasing department orders articles from outside manufacturers. All articles are classified to delivery date and order number.	Fig. II-17

ICUT. DATE	PALLET NAME	P1*	P2*	P3*	PALLET TOTAL	TOTAL	
6.29	970 NU504	2 ( 1.7)	24 ( 35.4)	5 ( 14.0)	31 ( 51.2)		1
	934 NU526	15 ( 16.1)	9 ( 32.2)	12 (166.5)	36 (236.9)		1
		17 ( 19.8)	33 ( 67.7)	17 (200.6)		67 ( 288.1)	
7. 2	946 NU523	0 ( 0.0)	0 ( 0.0)	5 ( 14.8)	5 ( 14.8)		1
	934 NU525	11 ( 16.8)	12 ( 34.2)	8 (104.4)	31 (155.4)		1
	934 81G	11 ( 5.1)	1 ( 2.5)	2 ( 3.4)	14 ( 11.0)		3
		22 ( 21.9)	13 ( 36.7)	15 (122.7)		50 ( 181.3)	
7. 3	979 54A	0 ( 0.0)	0 ( 0.0)	1 ( 15.6)	1 ( 15.6)		1
		0 ( 0.0)	0 ( 0.0)	1 ( 15.6)		1 ( 15.6)	
7. 4	980 UU1C	30 ( 23.5)	5 ( 19.4)	7 ( 86.9)	42 (129.9)		6
		30 ( 23.5)	5 ( 19.4)	7 ( 86.9)		42 ( 129.9)	
7. 6	970 B09P0	0 ( 0.0)	0 ( 0.0)	1 ( 5.9)	1 ( 5.9)		3
	970 B09S0	0 ( 0.0)	0 ( 0.0)	1 ( 5.9)	1 ( 5.9)		3
		0 ( 0.0)	0 ( 0.0)	2 ( 11.8)		2 ( 11.8)	
7. 9	980 UU1B	70 ( 99.8)	31 (101.6)	1 ( 1.9)	102 (203.3)		6
	946 NB6C5	6 ( 1.1)	0 ( 0.0)	0 ( 0.0)	6 ( 1.1)		1
	946 NB6C6	4 ( 0.7)	0 ( 0.0)	0 ( 0.0)	4 ( 0.7)		1
	946 NB6C7	4 ( 0.7)	0 ( 0.0)	0 ( 0.0)	4 ( 0.7)		1
	970 NB7C5	6 ( 1.4)	0 ( 0.0)	0 ( 0.0)	6 ( 1.4)		1
	970 NB7C6	6 ( 1.6)	0 ( 0.0)	0 ( 0.0)	6 ( 1.6)		1
	946 NU527	0 ( 0.0)	0 ( 0.0)	4 ( 26.8)	4 ( 26.8)		1
	979 3DA4P	42 ( 47.5)	9 ( 23.5)	0 ( 0.0)	51 ( 71.0)		2
		138 (152.8)	40 (125.1)	5 ( 28.7)		183 ( 306.5)	
7.10	979 UM3P0	5 ( 1.9)	0 ( 0.0)	0 ( 0.0)	5 ( 1.9)		3
	979 21A	11 ( 8.9)	4 ( 7.9)	0 ( 0.0)	15 ( 16.8)		1
	970 L06P0	5 ( 1.4)	0 ( 0.0)	0 ( 0.0)	5 ( 1.4)		3
	970 L06S0	5 ( 1.4)	0 ( 0.0)	0 ( 0.0)	5 ( 1.4)		3
	970 A05C0	6 ( 4.3)	0 ( 0.0)	0 ( 0.0)	6 ( 4.3)		3
	970 NB7C4	4 ( 0.7)	0 ( 0.0)	0 ( 0.0)	4 ( 0.7)		1
	970 NB7C7	6 ( 1.1)	0 ( 0.0)	0 ( 0.0)	6 ( 1.1)		1
	970 NB7C8	4 ( 0.7)	0 ( 0.0)	0 ( 0.0)	4 ( 0.7)		1
	946 NU524	0 ( 0.0)	0 ( 0.0)	5 ( 14.8)	5 ( 14.8)		1
	934 81H	12 ( 4.1)	0 ( 0.0)	0 ( 0.0)	12 ( 4.1)		3
	934 53ME	3 ( 2.1)	0 ( 0.0)	0 ( 0.0)	3 ( 2.1)		1
		61 ( 26.7)	4 ( 7.9)	5 ( 14.8)		70 ( 49.4)	
7.11	979 P0XSU	39 ( 33.5)	10 ( 37.1)	0 ( 0.0)	49 ( 70.6)		5
	979 NT581	28 ( 5.0)	0 ( 0.0)	0 ( 0.0)	28 ( 5.0)		1

Man-Pour (HR)

Number of pipe piece

ISSUED DATE 48. 6.22

\* P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>: production line

Fig. II-8 An actual copy of man-hour loading list

CUT, DATE	T O T A L	(H)										HR
		30	60	90	120	150	180	210	240	270	300	
6.29	67 ( 288.1)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
6.30	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
* 7. 1	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7. 2	50 ( 181.3)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7. 3	1 ( 15.6)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7. 4	42 ( 129.4)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7. 5	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7. 6	2 ( 11.3)	***	*****	*****	*****	*****	*****	*****	*****	*****	*****	
* 7. 7	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
* 7. 8	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7. 9	133 ( 308.5)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	#
7.10	70 ( 49.4)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.11	260 ( 275.2)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.12	254 ( 465.3)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	#
7.13	166 ( 147.6)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.14	140 ( 114.4)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
* 7.15	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.16	82 ( 42.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.17	130 ( 116.6)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.18	263 ( 542.5)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	#
7.19	75 ( 68.7)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.20	169 ( 188.2)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
* 7.21	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
* 7.22	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.23	202 ( 171.1)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.24	58 ( 45.4)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.25	164 ( 79.1)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.26	234 ( 391.3)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	#
7.27	234 ( 109.7)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.28	76 ( 58.6)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
* 7.29	0 ( 0.0)	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
		30	60	90	120	150	180	210	240	270	300	
Man-Hour (HR)												
- Number of pipe pieces												

Fig. 11-9 All actual copy of a man-hour loading graph for pipe shop

PRO. LINE PL (STEEL)

CUTTING DATE 5.49. 6. 7

NO.	MATERIAL	NOM. DIA	OUT DIA	THICK	SEQ. NO	N/C	SNO.	DRAWING NO.	CUT. LENGTH	SCRAP	FAB. PATH	F L A N G E			BOLT HOLD	
												START PRES.	DIA.	END PRES.		DIA.
1	STPG35-E	15	21.7	2.8	1		966D	NU051-32	5253	247	25B				0	
2	STPG38-E	15	21.7	2.8	2		953E	UU-3A-2	1261		25B	10K	15	10K	15	90
					3		966E	73C-6	4163	76	25B	10K	15	10K	15	53
3	STPG38-E	15	21.7	2.8	4		953E	UU-3A-3	1693		25B	10K	15	10K	15	-30
					5		966D	NU051-31	3753	54	25B					0
4	STPG38-E	15	21.7	2.8	6		966E	73C-7	656		2FA			10K	15	90
					7		966E	73C-16	840		25S	10K	15	10K	15	90
					8		966E	73C-24	840	3164	25S	10K	15	10K	15	90
5	SGP-E	15	21.7	2.8	9		966E	73C-14	1240		25F					0
					10		966E	73C-4	3782	476	2FA			5K	15	90
6	SGP-E	15	21.7	2.8	11		966E	73C-13	556	ZAN*	2FA			5K	15	90
7	SGP-E	20	27.2	2.8	12		966E	73C-21	475		2BA					0
					13		966E	73C-17	1027	ZAN*	2SA					0
8	SGP-E	25	34.0	3.2	14		966D	NU051-25	5490	10	25F					0
9	SGP-E	25	34.0	3.2	15		966D	NU051-26	5490	10	25F					0
10	SGP-E	25	34.0	3.2	16		966D	NU051-27	5490	10	25F					0
11	SGP-E	25	34.0	3.2	17		966D	NU051-40	1990		25F					0
					18		966D	NU051-51	2402	1108	2BA					0
12	STPG38-E	25	34.0	3.4	19		995D	NU141-7	5490	10	25F					0
13	STPG38-E	25	34.0	3.4	20		995D	NU141-4	1697		2BA					0
					21		995D	NU141-6	3790	13	25F					0
14	STPG38-E	25	34.0	3.4	22		995D	NU141-5	115	ZAN*	25F					0
15	STPG38-E	25	34.0	3.4	23		995D	SEBNO-26	1916		25B					0
					24		966D	NU051-43	2694	690	25A					0
16	STPG38-E	25	34.0	3.4	25		995D	SEBNO-27	995		25F					0
					26		966E	44A-10	1831		2BA					0
					27		995D	NU141-3	2643	31	25B					0
17	STPG38-E	25	34.0	3.4	28		966E	73C-8	1550		25F					0
					29		995D	SEBNO-26	1643	2307	2BA					0
18	STPG38-E	25	34.0	3.4	30		966E	22ME-9	643		2BA					0
					31		966E	22ME-7	703	ZAN*	2BA					0

CUTTING DATE 5.49. 5.31

\* shows utilization of remaining pipe

Fig. 11-10 An actual copy of pipe cutting plan

** PRO. LINE P1 **			***** MATERIAL LIST *****							PAGE 1					
** CUT DATE 22-9-1976 **															
** STEEL PIPE (40-150) **															
SYSTEM	SHIP NO.	ACCOUNT NO.	MATERIAL	NOM. DIA.	SCHEDULE	Q'TY	ARTICLE CODE	LENGTH	WEIGHT	DELIVERY DATE	DWG. NO.	ORDER NO.			
AD	CS1095E	P 1605	STPG38-E	40	40	1	140554	5.5	22.53						
SC	CS1095D	P 1606	STPG38-E	40	40	2	140554	11.0	45.07						
1F	CS1095E	P 0813	STPG38-E	40	40	1	140554	5.5	22.53						
2L	CS1044E	P 0805	STPG38-E	40	40	1	140554	5.5	22.53						
4D	CS1094E	P 0804	STPG38-E	40	40	2	140554	11.0	45.07						
4W	CS1044E	P 0810	STPG38-E	40	40	3	140554	16.5	67.60						
SD	CS1044D	P 1607	STPG38-E	40	80	4	140556	22.0	120.37						
AV	CS1095E	P 1607	STPG38-E	50	40	1	140558	5.5	29.94						
BL	CS1095D	P 1602	STPG38-E	50	40	3	140558	16.5	89.82						
CA	CS1044D	P 1609	STPG38-E	50	40	8	140558	44.0	239.53						
SC	CS1095D	P 1606	STPG38-E	50	40	2	140558	11.0	59.88						
1F	CS1095E	P 0813	STPG38-E	50	40	1	140558	5.5	29.94						
4F	CS1094E	P 0801	STPG38-E	50	40	1	140558	5.5	29.94						
5L	CS1094E	P 0805	STPG38-E	50	40	3	140558	16.5	89.82						
AD	CS1094E	P 1605	STPG38-E	50	80	1	140560	5.5	41.03						
2L	CS1044E	P 0805	STPG38-E	50	80	1	140560	5.5	41.03						
BL	CS1095D	P 1602	STPG38-E	65	40	2	140562	11.0	100.30						
SD	CS1095D	P 1607	STPG38-E	65	40	1	140562	5.5	50.15						
WD	CS1095D	P 1601	STPG38-E	65	40	1	140562	5.5	50.15						
1S	CS1044E	P 0802	STPG38-E	65	40	1	140562	5.5	50.15						
7H	CS1094E	P 0806	STPG38-E	65	40	2	140562	11.0	100.30						
CO	CS1044E	P 1901	STPG38-E	80	40	1	140566	5.5	62.37						
EP	CS1044D	P 0602	STPG38-E	80	40	1	140566	5.5	62.37						
*****															
CALCULATED DATE 14-9-1976															

Fig. II-11 Copy of material list (Pipes)



\*\* PRO. LINE P1 \*\*

\*\* CUT DATE 22-9-1976 \*\*

\*\*\*\*\* MATERIAL LIST \*\*\*\*\*  
(FLANGE)

PAGE 1

\*\* FLANGE \*\*

SYSTEM	SHIP NO.		MATERIAL	NOM. DIA.	Q'TY	ARTICLE CODE	Q'TY	WEIGHT	DELIVERY DATE	DWG. NO.	ORDER NO.
5K SLIP	CS1080E	P	SS41	15	4	582103	4	1.20			
5K SLIP	CS1094D	P	SS41	15	8	582103	8	2.40			
5K SLIP	CS1037D	P	SS41	20	12	582104	12	4.44			
5K SLIP	CS1044E	P	SS41	20	7	582104	7	2.59			
5K SLIP	CS1080E	P	SS41	20	17	582104	17	6.29			
5K SLIP	CS1095E	P	SS41	20	6	582104	6	2.22			
5K SLIP	CS1037D	P	SS41	25	1	582105	1	0.45			
5K SLIP	CS1037F	P	SS41	25	8	582105	8	3.60			
5K SLIP	CS1044E	P	SS41	25	12	582105	12	5.40			
5K SLIP	CS1080E	P	SS41	25	3	582105	3	1.35			
5K SLIP	CS1094D	P	SS41	25	1	582105	1	0.45			
5K SLIP	CS1037D	P	SS41	40	12	582108	12	9.96			
5K SLIP	CS1037F	P	SS41	40	3	582108	3	4.15			
5K SLIP	CS1044D	P	SS41	40	4	582108	4	3.32			
5K SLIP	CS1044E	P	SS41	40	73	582108	73	60.59			
5K SLIP	CS1080E	P	SS41	40	30	582108	30	24.90			
5K SLIP	CS1094D	P	SS41	40	17	582108	17	14.11			
5K SLIP	CS1095E	P	SS41	40	3	582108	3	4.15			
5K SLIP	CS1037D	P	SS41	50	24	582109	24	23.68			
5K SLIP	CS1044E	P	SS41	50	35	582109	35	37.45			
5K SLIP	CS1080E	P	SS41	50	17	582109	17	18.19			
5K SLIP	CS1094D	P	SS41	50	2	582109	2	2.14			
5K SLIP	CS1095E	P	SS41	50	15	582109	15	16.05			

CALCULATED DATE 14-9-1976

Fig. 11-12 Copy of material list (flange)

[illegible]

1247 CS1100-TDB4S-10 50 P-3SF  
STPG38-E(# 80) CK  
12. 7 CS1100 105S- 25 50 P-3SF  
STPG38-EC# 80) CK

*Fig. 11-14 Identification Number Label*

75

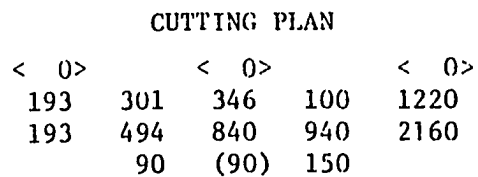
[illegible]

Fig. 11-15 Numerical pipe piece list

(Pipe)

*** PALLET TABLE (A) *** (PIPE) PAGE 1									
JOB ORDER CS1005 OUTFITTING CODE 22202 DELIVERY DATE 18-7-75									
NO.	PIPE NO.	PIPE	MATERIAL	NO.	THICK.	PAINT	INSP.	H. PERS.	WEIGHT
1	W 55-9		STPY-41	500		NL			210.8
2	W 55-10		STPY-41	500		NL			397.5
3	W 55-11		STPY-41	500		NL			220.8
4	W 55-12		STPY-41	500		NL			249.7
5	W 55-13		STPY-41	500		NL			181.0
6	W 55-14		STPY-41	500		NL			195.6

(Piece)

** PALLET TABLE (B) **									
OUTFITTING CODE 22202 3 PAGE CAL. DATE 19-6-75									
JOB ORDER CS1005 ARTICLE (PIECE) PALLET NAME (U1B) DELIVERY DATE (18-7-75)									
LIST NO	CODE	SYM.	PRES.	N.D.	MATERIAL	QUANTITY	WEIGHT	HOUR	DRAWING NO. ORDER NO. LOT .. COMMENT ..
FS	41	F*	20	15	SUS3	1	2.25	5080073	951188 4
FS	42	F*	20	25	SUS3	2	6.70	5080073	951188 4
PT	1101	T*	5	250	SGPE	2	106.240	5080047	550246

(Valve & Cock)

** PALLET TABLE (C) **									
OUTFITTING CODE 22202 10 PAGE CAL. DATE 19-6-75									
JOB ORDER CS1005 ARTICLE (VALVE & COCK) PALLET NAME (U1B) DELIVERY DATE (18-7-75)									
LIST NO	CODE	SYM.	PRES.	N.D.	MATERIAL	QUANTITY	WEIGHT	HOUR	DRAWING NO. ORDER NO. LOT .. COMMENT ..
EV	23	591450	FN	5	050L	1	13.45		
UV	25	FNX	5	250	FC20	1	165	1.20	945800
BV	31	FNX	5	250	FC20	1	160	1.20	945798
DV	32	FNX	5	250	FC20	1	120	1.20	945796

(Auxiliary Machine)

** PALLET TABLE (D) **									
OUTFITTING CODE 22202 2 PAGE CAL. DATE 19-6-75									
JOB ORDER CS1005 ARTICLE (AUX. MACHINE) PALLET NAME (U1B) DELIVERY DATE (18-7-75)									
LIST NO	ARTICLE	MATERIAL	NO	WEIGHT	ORDER NO.	DRAWING NO.	COMMENT		
PUB- 2	FIRE & G.S. PUMP		1	1,810	502275		KOUSU 1Q. CULTURE B		
	MOKIDAI 10		1	750	461893	2062008			
	LINER	SS41	2	9	551116	5069042	130	200	33 22
	LINER	SS41	2	9	551116	5069042	140	210	33 20
	LINER	SS41	5	4	551116	5069012	70	70	33 22
	LINER	SS41	5	5	551116	5069042	80	80	33 20

(Bolt)

*** PALLET TABLE (E) *** (BOLT) 19-6-75						
SHIP. NO 1005 CODE 22202 DELIVERY DATE 18-7-75						
MATERIAL	SIZE	LENGTH	QUANTITY	WEIGHT	TYPE	
S35C	M24	135MM	97	85.97	DOUBLE NUT (GREEN)	
	M22	120MM	55	32.29		
		115MM	290	165.19		

(Packing)

*** PALLET TABLE (F) *** (PACKING) 19-6-75			
SHIP. NO 1005 CODE 22202 DELIVERY DATE 18-7-75			
TYPE	STANDARD	N.D.	NO.
CASNET *OR*	20K	257A	2
		200A	2
		155A	8
		100A	7

Fig. 11-16 Copies of actual palletting table

JOB NO. CS0976E				*** DELIVERY DATE LIST (VALVE AND COCK) ***										CAL. DATE 24TH OCT. 1972		PAGE - 1-	
*2	*3	*4	*5	1471209	1471225	1480110	1480134	1480210	1480220	1480312	1480420	1480507					
BV	5	150	FC25	753905			753905										
BV	5	175	FC25	753905			753905	753905									
BV	5	200	FC25	753905			753905		753905								
BV	5	250	FC25	753905			753905										
BV	5	300	FC25	753905			753905										
BV	5	350	FC25				753905	753905	753905								
BV	5	400	FC25				753905										
BV	5	600	FC25	753905													
BV	5	700					754390				754390						
											754882						
BV	10	100	FC20	753905													
BV	10	100	SC49		753639												
BV	10	125	FC20				753905										
BV	10	125	SC49		753639												
BV	10	150	FC25	753905													
BV	10	150	SC49		753639												
BV	10	200	SC49		753639												
BV	10	400	SC49		753639												
BV	10	600	SC49	753639													
ESDV	5	65	SC49								753906						
ESDV	5	80	SC49				753906										
ESDV	5	100	SC49	753906			753906										
FCGX	20	4															
FCX	5	50L	FC20	753909			753909										
FCX	5	65	FC20						755611								
FCX	10	20	BC								753908						
											783906						
FCX	10	20	BC6								783906						

REMARK

\*1: DELIVERY DATE OF LOT  
471209 SHOWS 9TH DEC. 1972  
DAY  
MONTH  
YEAR

\*2: SYMBOL

\*3: PRESSURE

\*4: NOMINAL DIAMETER

\*5: MATERIAL

REMARK

\*1: DELIVERY DATE OF LOT  
 471209 SHOWS 9TH DEC. 1972.  
 DAY  
 MONTH  
 YEAR

\*2: SYMBOL

\*3: PRESSURE

\*4: NOMINAL DIAMETER

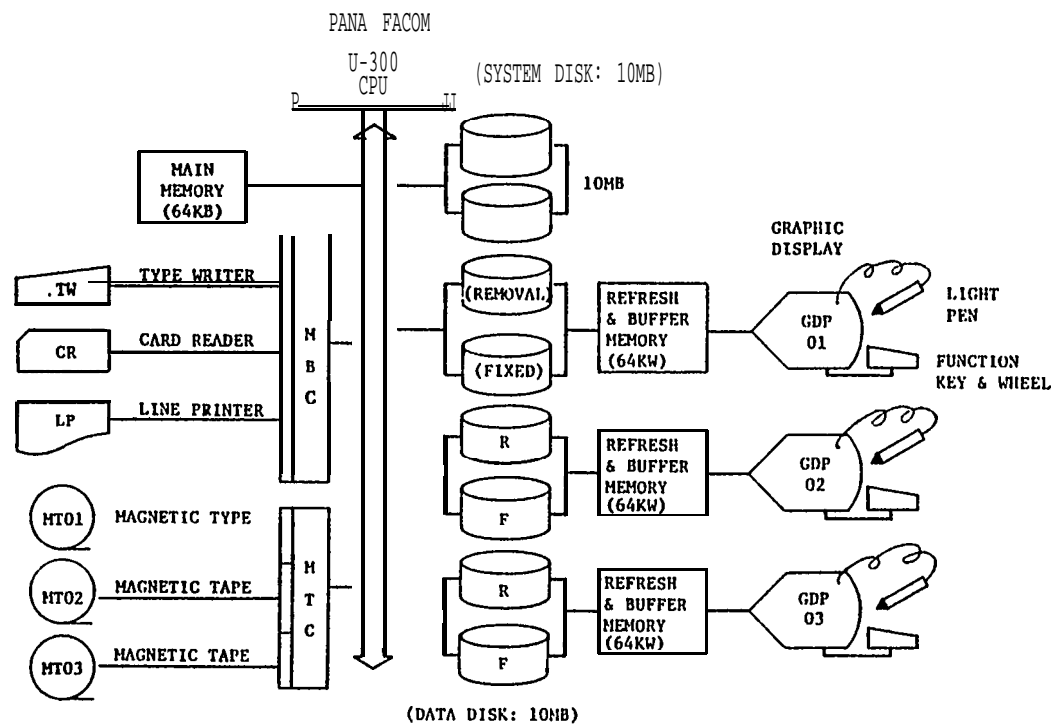
\*5: MATERIAL

Fig. II-17 Delivery date control list

# G. Computer Configuration to Accomplish the Software Package

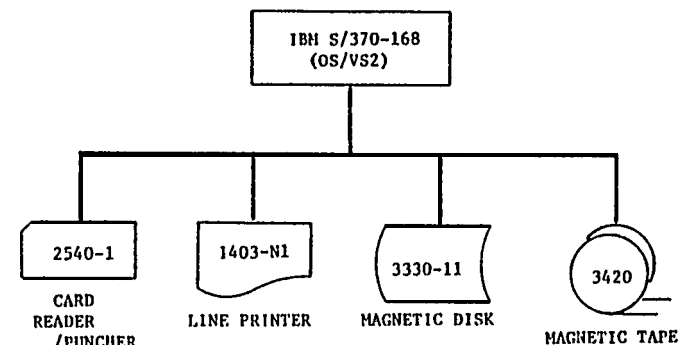
Shown below is one example in case of Mitsui Chiba Works  
The machine can be replaced by the one having equivalent capacity.

## MINI-COMPUTER WITH GRAPHIC DISPLAY FOR GPS



Core size ; 64K Byte  
One work ; 16 Bits  
Addition ; 0.8 ~ 1.8μS  
Floating point multiply ; 16.8 ~ 28.6μS

## HOST COMPUTER



User's program area in main memory ; 384KB  
Card reader/puncher ; 1 set  
Line printer ; 1 set  
Magnetic disk equipment ; 1 spindle  
Magnetic tape equipment ; 2 devices

Fig. 11-18 Computer configuration to accomplish the software package

## **Section IV**

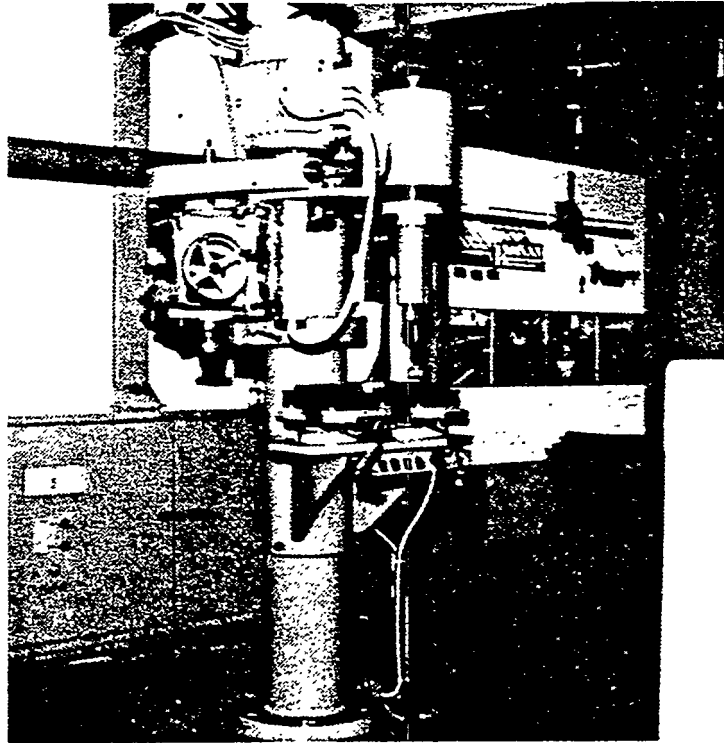


## **Section IV**

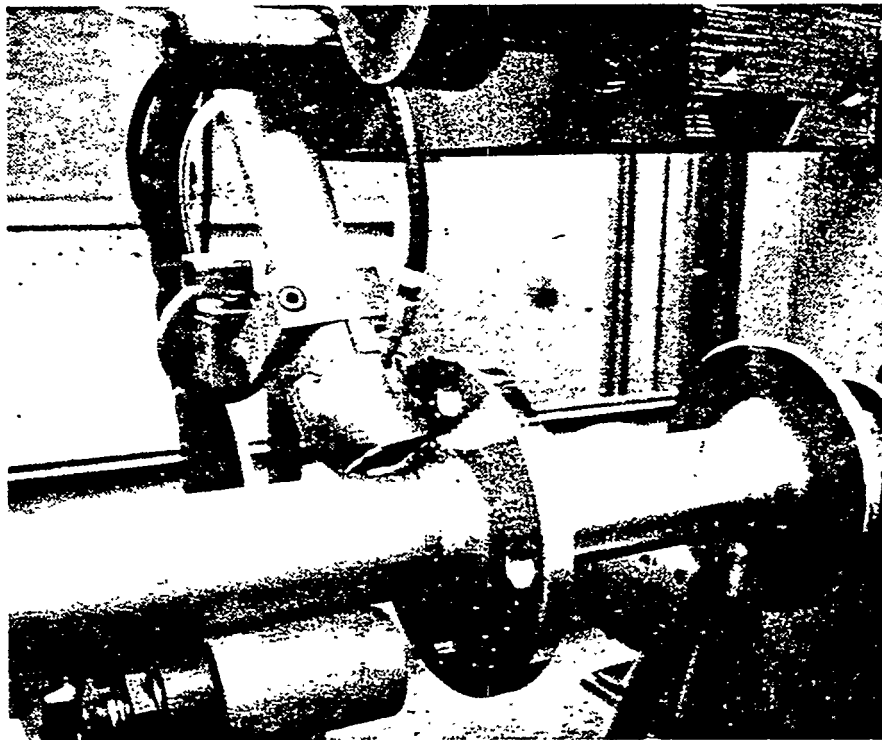
Advanced Research and Development

### **INDEX**

- A. General
- B. Van-Stone Couplings
- C. Cypress Welding Research and Development
- D. ESAB Industrial Robot Welding  
Research and Development
- E. T/Drill Branch Collaring 90 Degree  
Research and Development
- F. Machine Cutting Branches



*T/Drill pipe collaring for 90 degree pipe branches.*



*Semi-automatic plasma welding process.*

## A. General

During our research effort, some advanced processing equipment has been identified.

1. Van-Stone Couplings versus Weld Joints
2. Cypress Engineering Company Orbiting Pipe Saddle Welding
3. ESAB Company "Robot" Welding
4. T/Drill 90 Degree Branch Collaring

These four items relate to the sub-assembly area of the automated pipe facility. This is the area where application of individual automatic equipment is the most challenging.

## B. Van-Stone Couplings Versus Weld Joints

Cost effectiveness of subject couplings has been demonstrated. It is a regulatory body approved alternate to weld joints. Research is proceeding for production application of subject couplings.

## C. Cypress Engineering Company Orbiting Saddle Welding

This machine is in the developmental stage. It has been established that the subject tooling can follow the complex contours set forth by pipe saddle joints. The Cypress Engineering Company equipment has been extensively modified as evaluation of equipment has progressed. Presently, this unit has a mechanical linkage capable of optimum varying torch angles for any place in its 360 degree orbit. Additionally, it can simultaneously oscillate to produce a weld weave pattern. The oscillation is a fixed equal dwell. Since most of the saddle joint is essentially a horizontal position weld, a variable dwell oscillation pattern should be pursued. Test welds made to date indicate feasibility.

This welding process is approved for nuclear construction with saddle in joints. Further development is required for application with P-1 ship systems. This process has proved very economical for processing piping with diameters of 30 inches and above.

## D. ESAB Company "Robot" Welding

1. Welding Fair-Essen, Germany-1977

It was observed by our technical people that use of industrial-' robots" for welding is accelerating at a rapid pace in Europe. Basically, "robots" are divided into two categories.

- a. Manually Programmed-e.g. Hobart-Tralfa
- b. X-Y-Z Axis Programmed-e.g. ESAB-ASEA

Contact with technical people in Europe indicates category b. better conforms to accuracy requirements for welding.

2. "Robot" Welding of Pipe Saddles

Since September, 1977, research has progressed with the "robot" equipment. The "robot" is a more expensive alternate to the Cypress equipment with a wider field of application. It should be noted that this equipment can be utilized for high production rate and repetitive assembly work such as (a) Pipe Hangers; (b) Small Foundations; and (c) Brackets, as well as Pipe Branch Weldments. There are numerous repetitive assemblies in ships. Historically, this work is accomplished in fabrication or sheet metal shops. This work could be redirected to the automated pipe assembly area.

## E. T/Drill 90 Degree Branch Collaring

This equipment makes "pull outs" on pipe and eliminates the need for purchased T-fittings. Avondale Shipyards has purchased two of these units.

Cost analyses indicate the use of "pull outs" can save as much as 98 percent of the material cost (conventional joints) per ship set on a series of Navy vessels currently under construction at Avondale.

Further research with this equipment will involve studying welding systems for the development of procedures on such materials as carbon steel, copper-nickel and 300 Series stainless steel, utilizing the T/Drill collar for joint preparation.

Research will continue to determine the feasibility of automating the welding of T-Drill weld joints.

## F. Machine Cutting Branches

During the research efforts on 90 degree fitting and welding of branches, the hole in the main body pipe and the shape of the branch has been accomplished by burning. In order to improve this weld joint, it is recommended that additional research efforts be directed toward the feasibility of machine cutting the hole as well as the contoured end of the branch pipe.



**Welding robot A30 A**



## Mechanized welding - from a technical point of view

When mechanizing or automating a welding process it is often necessary, as in practically all mechanization, to adapt the workpiece to the automatic process in question. In the case of arc welding, this is a requirement of particular importance since in itself, arc welding is a relatively complicated process which normally requires an intimate interaction between man, machine and workpiece. Long series were previously called for if profitability was to be reached. This meant that short series, varying series, and components in which the joints lacked sufficient accuracy, continuity or regularity were seldom suitable for profitable mechanization with the techniques available.

Under ideal conditions, where the above requirements are fulfilled a

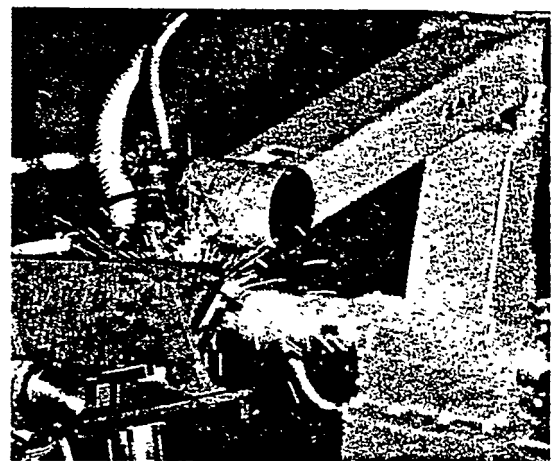
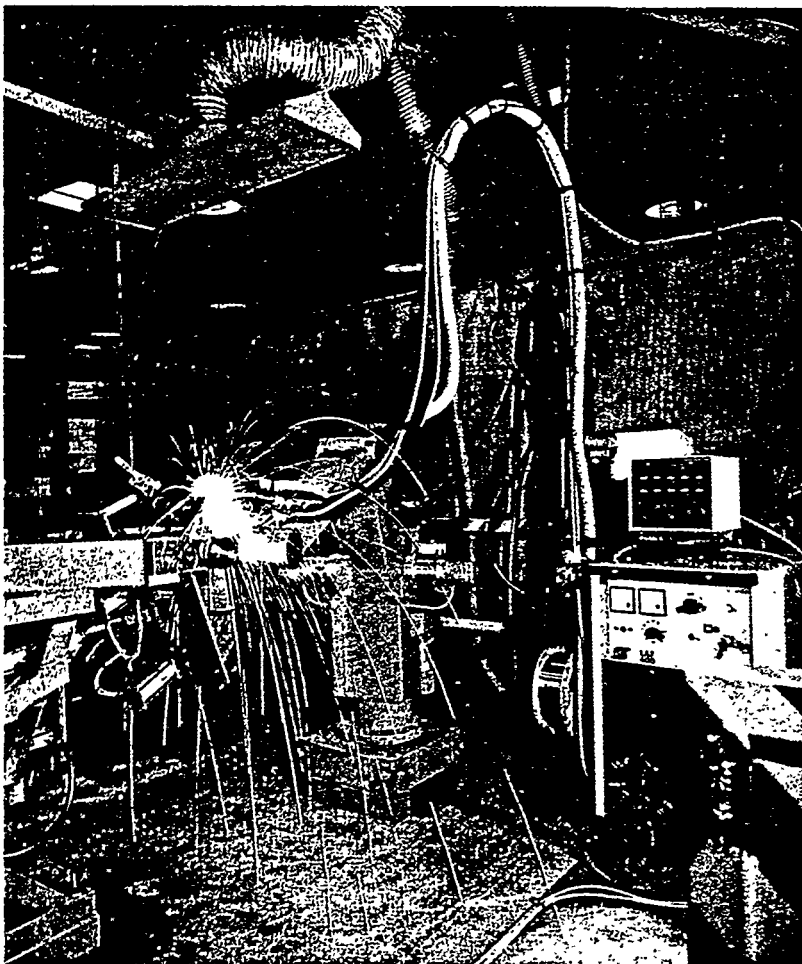
product-adapted machine is often the best and most profitable solution. For example, a number of arcs can be operated simultaneously or in sequence which in most cases, understandably, makes for high production rates. In general, this type of facility or mechanical welding equipment is used for peripheral or continuous straight welds; this applies to large as well as small production facilities.

### Robot arc welding

Thanks to the development of semi-automatic welders in the late 1950's, gas metal-arc welding made its break-through in industry and today, semi-automatic gas metal-arc welding is widespread in the industrialized world. For many years, there has been a definite need of a more advanced, mechanized arc welding machine for the type of workpiece which does not satisfy the requirements on series length, joint position and regularity.

This is probably most evident in the case of small and medium-size components.

Almost in every welding shop, much can be gained from improvements in the work environment. To achieve such improvements and simultaneously to eliminate tiresome and monotonous jobs within the welding industry has been one of the principal aims of ESAB'S development group for a considerable time. Through significant advancements in the field of robot technology, it is now possible to carry out gas metal-arc welding as well as resistance welding/spot welding with industrial robots to a sufficiently high level of accuracy for a substantial part of the industry's welded products. In this field, the ESAB A30 A Welding Robot is a leading contender.



2



Figs. 1 and 2. Robot welding of car details fine - gauge.

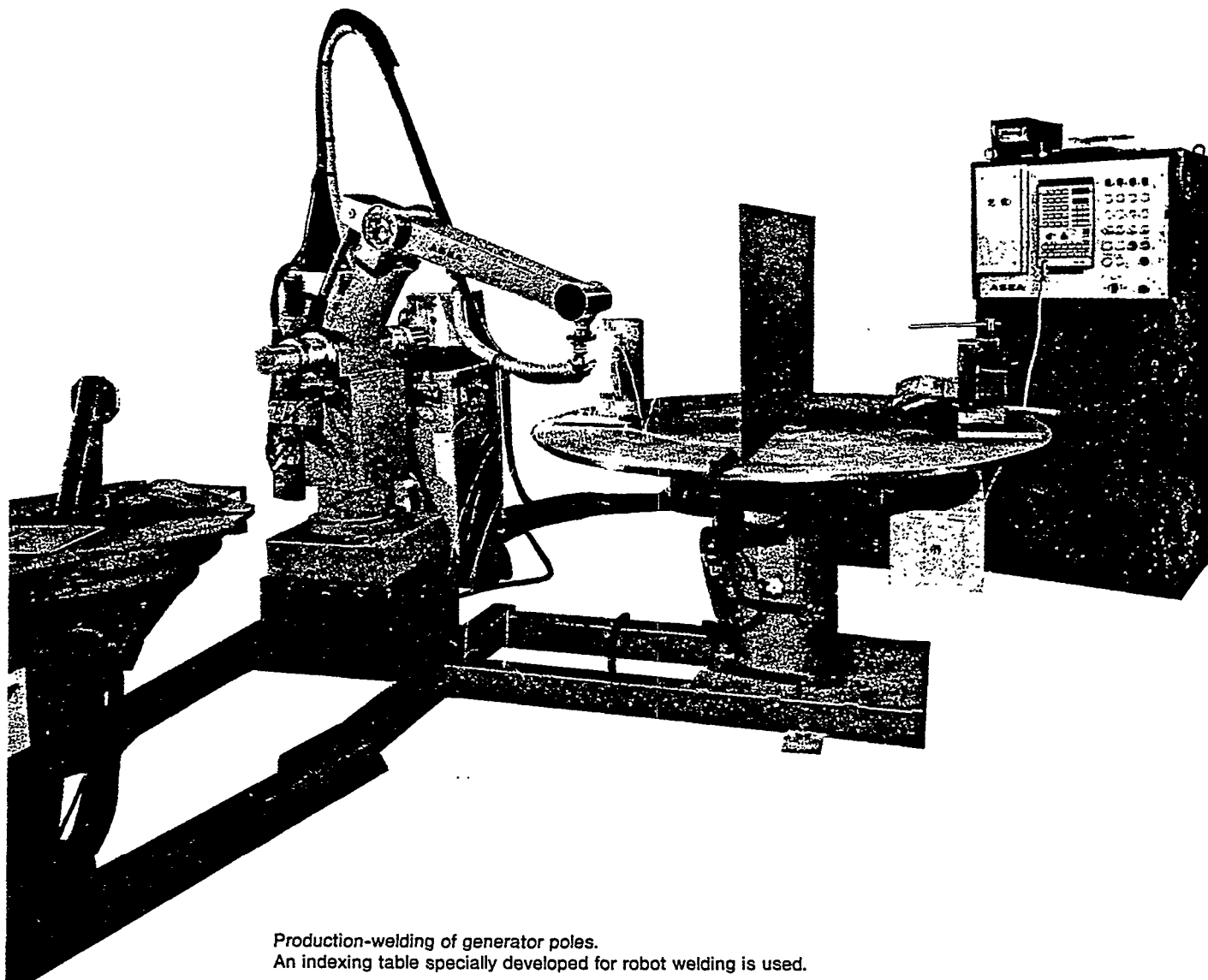
ESAB here presents the ASEA welding robot, especially designed for arc welding. The most significant advantages of this system can be summarized as follows:

- Improvement in work environment due to elimination of tiresome and monotonous jobs and the extraction of welding fumes.
- Significantly increased production.
- High, consistent welding quality.
- Versatile equipment, suitable for a great variety of workpieces.
- Short operation time, which reduces processing time.
- Low capital expenditure requirement compared with type restricted welding equipment.
- Easily operated and programmed.
- Generally adaptable to existing designs.

#### When to use robot welding

As previously mentioned, type-restricted, mechanized or automated welding equipment should be used for products which are to be manufactured in long series and where the geometry of the joints is uncomplicated. In some cases, type-restricted equipment can be modified to be used for a number of different workplaces or for different versions of the same workpiece. Furthermore, the welding of uncomplicated circular and linear joints can often be automated by using standard circumferential welding positioners or automatic column and booms. In order to attain good results, the following applies to both type-restricted equipment as well as welding robots.

- Material possessing good weldability. must be used.
- The material must be free from paint, impurities, grease, oil, scale etc.
- The joints must be well prepared and offer good fit.
- The workpieces must be uniform or the positioning of the joints be relative to each other or correspond to a reference point (datum plane, hole or edge). Permissible deviations vary from case to case, but generally speaking, the lighter the materials to be welded, the tighter the tolerance required. The type of joint is also of importance, as are the requirements made on penetration, weld appearance, strength etc.

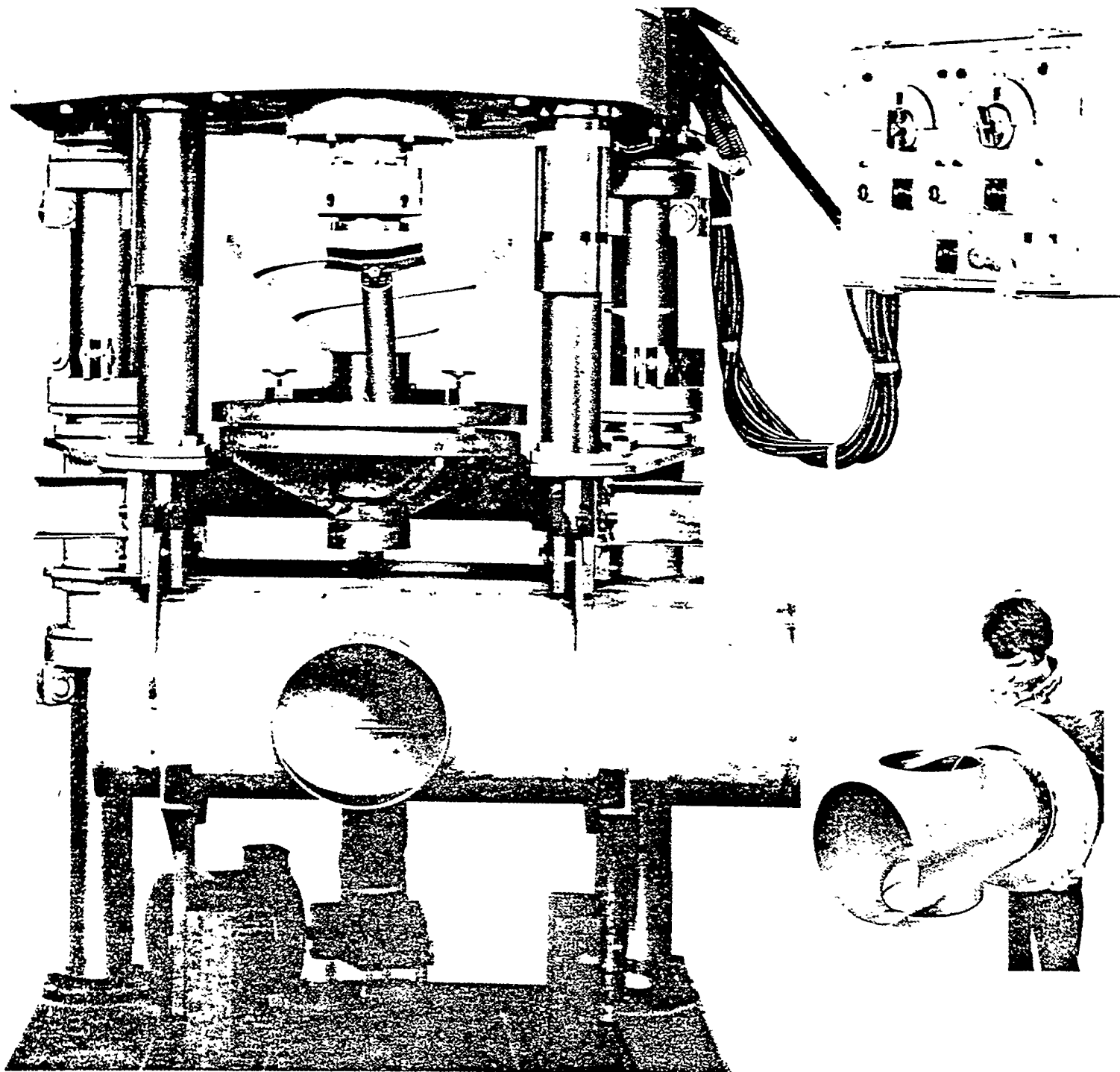


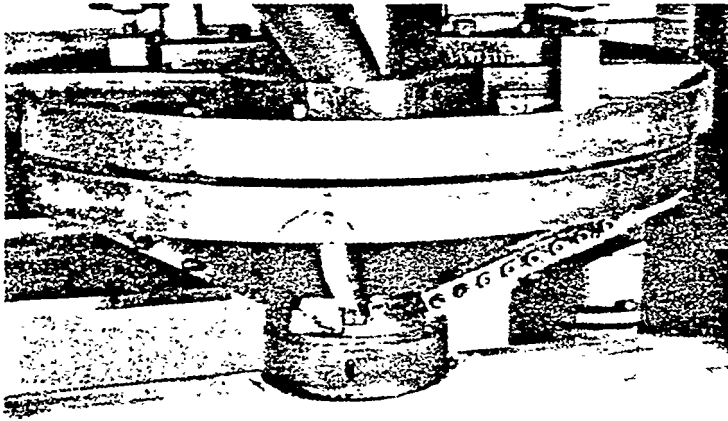
Production-welding of generator poles.  
An indexing table specially developed for robot welding is used.

# T/DRILL type 500

## ADVANCE PIPE AND SHEET BRANCHING METHOD

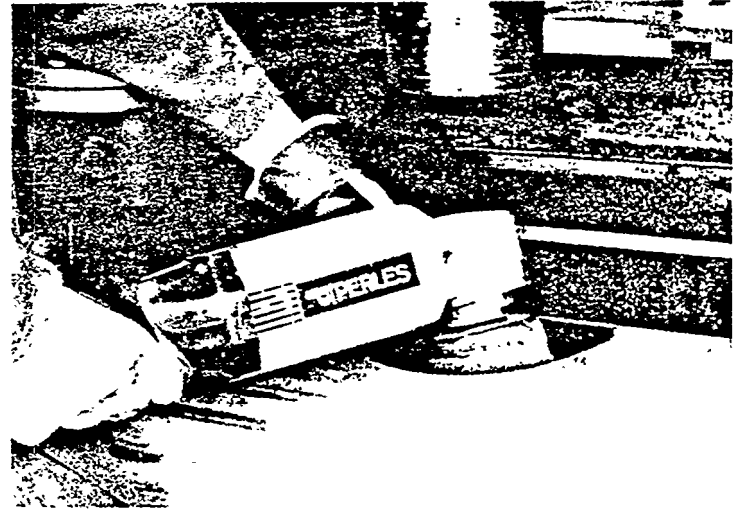
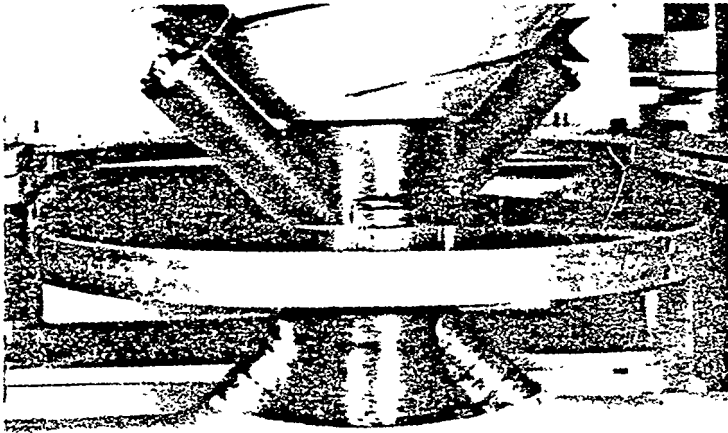
Formed collars from 5" to 20" in 20 minutes  
per collar. Increased flow properties, joint quality  
and joint strength! Decreased material costs,  
labor cost and joint inspection cost.





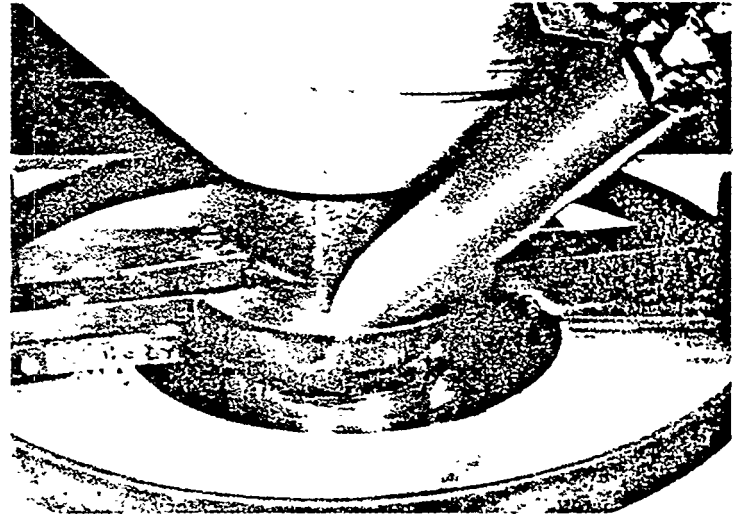
## STEP 1/

Hole saw and conical cutter  
form elliptical pilot hole



## STEP 2/

Machine grinding of  
edge to finish collar



## STEP 3/

Machine forms collar  
utilizing formation pins

## STEP 4/

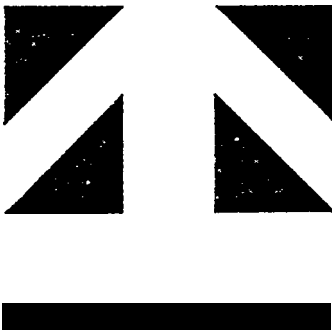
Machine mills edge  
to finish collar

### TYPE 500:

- Eliminates— T-joints and flanges
- Eliminates— Extra welds and x-rays
- Eliminates— Labor and materials for miter joints
- Eliminates— Stocking of joint pieces
- Eliminates— Weaknesses at branching points

### SPECIFICATIONS

- Capacity: Collar diameters-5" to 20"  
Max. main pipe O. D.-40"  
Max. wall thickness-1/4" stainless steel  
-5/16" soft steel
- Height: 106"
- Width: 51"
- Depth: 63"
- Weight: 5000 lbs.
- Connections: 220/440 V 30 ph 60 Hz  
12 hp.  
Air-100 P.S.I.



T/DRILL

727 W. ELLSWORTH, BLDG. 8/ ANN ARBOR, MICH. 48104  
TELEPHONE 313-995-2187



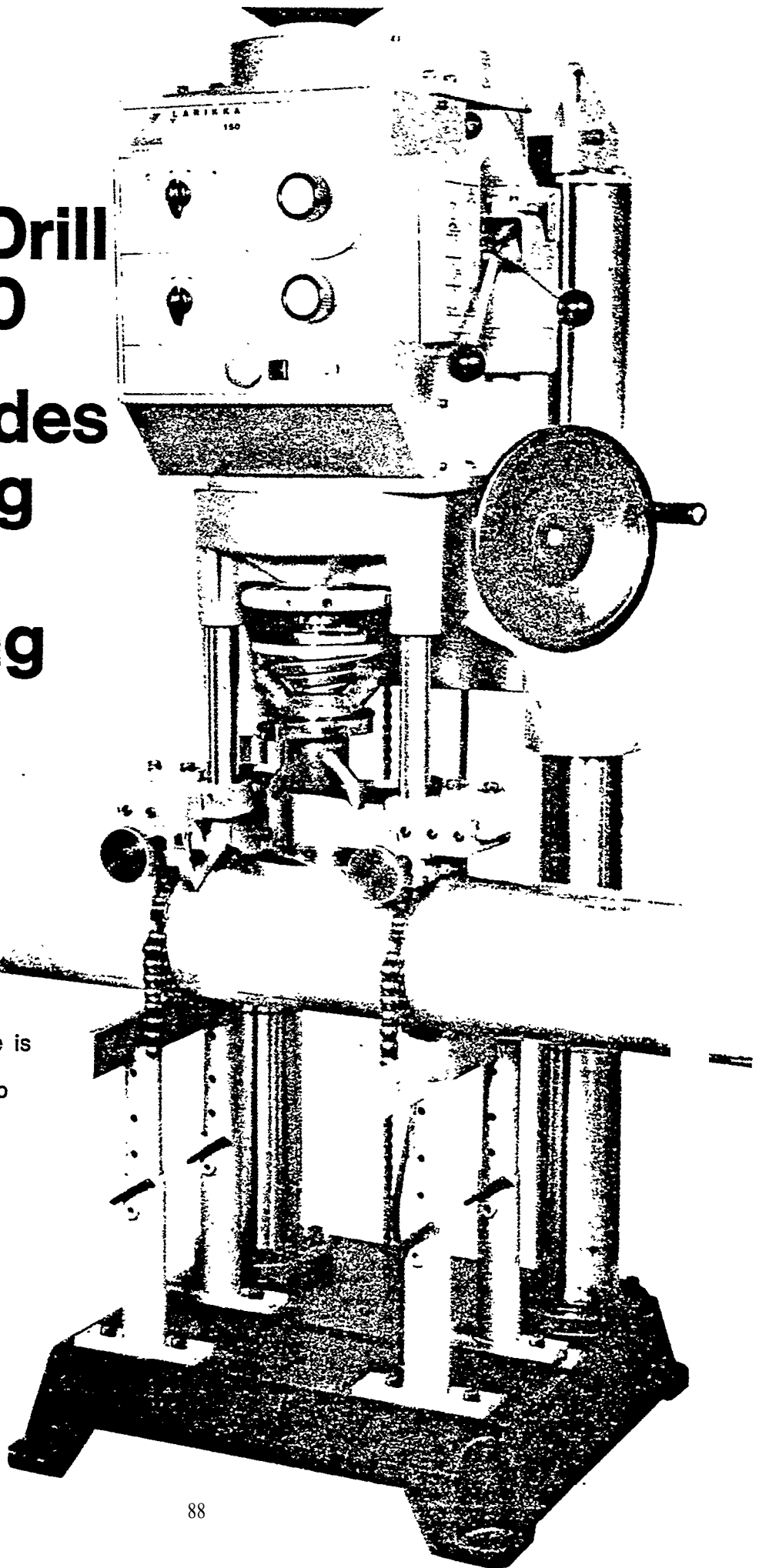
# Larikka T-Joint Drill Type 150

## Supercedes Prevailing Pipe Branching Methods

Putting a branch on a pipe is a problem.

A pipe branch is expensive to make if you use a separate T-part. You have to pay for the part itself and for linking it up to the main pipe and checking the connections.

And if you cannot utilize a branch part the traditional methods are uneconomical on account of their slowness and because of machine expenses.



## Type 150 provides a short-cut

A T-Joint Drill Type 150 can work the hole and the collar straight onto a pipe in 5-15 minutes.

Owing to the collar the pipe branch will not impede the flow.

And there is no separate branch part.

Costs are saved on pipe parts and on work and x-ray checks of the two connections joining the T-part to the main pipe.

### Pipe materials

Copper

Aluminum, brass

Copper, nickel

Stainless steel

Steel

### Operating range of collaring heads

branch pipe diameter

168	Collaring Head No. 5	S= 4 mm wall thick- ness is workable when collar dia- meter is not larger than 0,85 of the main pipe diameter
	Main pipe wall thickness S=3 (4)	
120	Collaring Head No. 4	
	Main pipe wall thickness S=3 (4)	
90	Collaring Head No. 3	
	Main pipe wall thickness S=3	
76	Collaring Head No. 2	Main pipe wall thickness S=2
	Main pipe wall thickness S=2	
46	Main pipe wall thickness S=2	
	42      48      76      90      120      168-400	
	main pipe diameter	

## Approvals

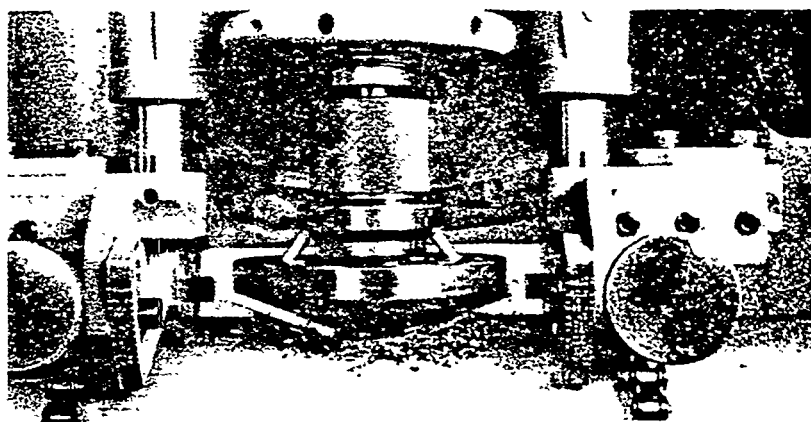
The Technical Research Centre of Finland has tested and the Technical Inspectorate has given a resolution (1865/210/76) of the use of Larikka T-Joint Drill Method in the manufacture of collared branches.

On the basis of the above Det Norske Veritas has given a restrictive approval (October 14, 1976) for the use of the method.

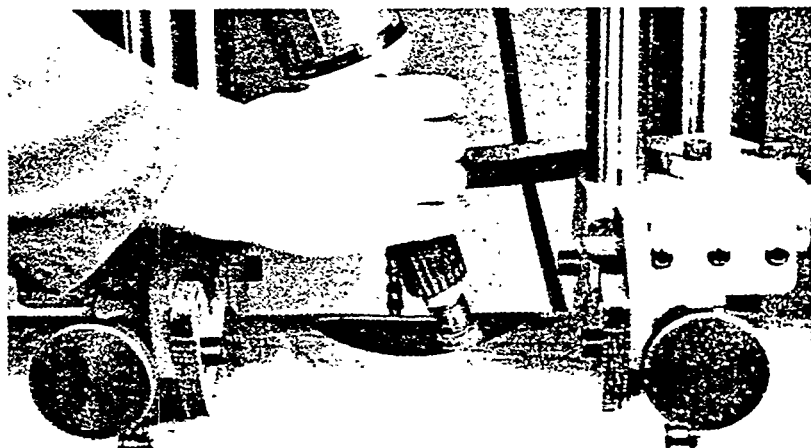
### Manufacturer:



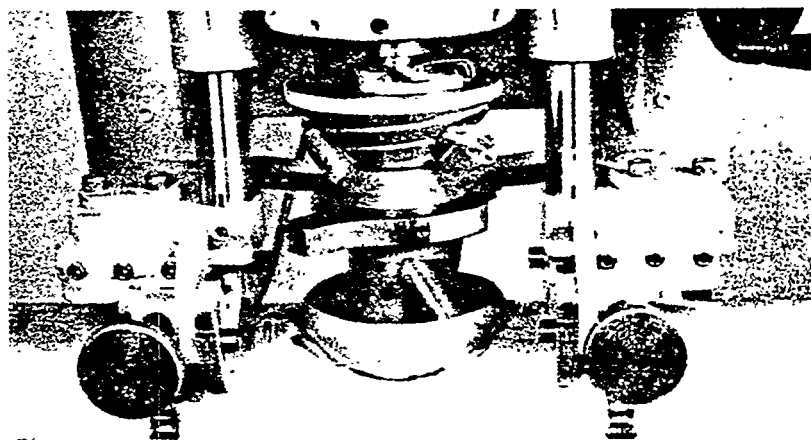
**LARIKKA OY**  
01630 Vantaa 63  
Finland  
Telephone: 90-847 077  
Cables: Latool



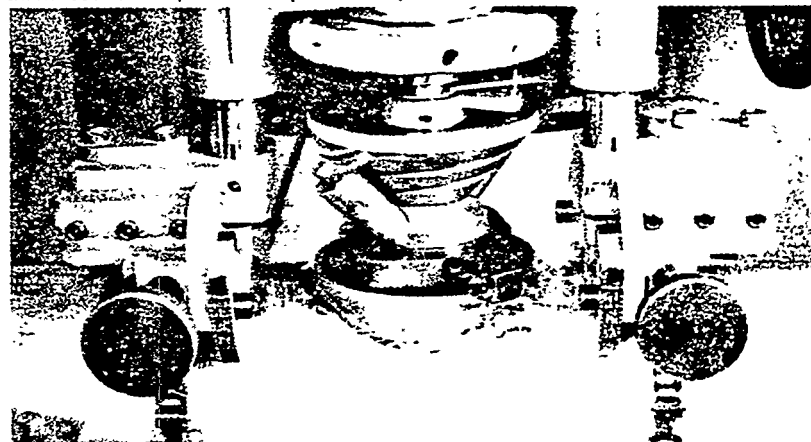
Machine drills elliptical pilot hole.



Edges of ellipse are filed with a machine file.



Machine draws on collar with aid of the formation pins of the collaring head. The adjustment of the head is continuous. The effect of the pipe wall thickness is compensated by a fine adjustment system.



Machine then works the collar edge for abutment joint.

## Section V

## **Section V**

Equipment Suppliers

### **INDEX**

- A. General
- B. Pipe Shop Equipment Suppliers
- C. Hardware Systems Suppliers
- D. Software Package Suppliers

## A. General

This section is designed to provide the reader with a list of companies that supply automatic or semi-automatic equipment. It must be noted that there are numerous companies in the world that manufacture this type of equipment. However, only a few major suppliers are mentioned in this section.

The equipment listed under the heading of Pipe Shop Equipment Suppliers can be acquisitioned individually. The machines are automatic or semi-automatic, and can be integrated into a production system with modifications.

There are five companies that can provide a semi-automatic or automatic pipe fabrication facility. These systems, however, are limited as to pipe size and alloy mix. These companies are listed under the heading of Semi-Automatic or Automatic Pipe Fabrication Systems Suppliers.

A software package is essential to the efficient operation of a semi-automatic or automatic pipe fabrication facility. Five suppliers are listed. It must be noted that in the near future a software package of United States' origin will be available, which will provide the pipe detailing function.

This system is being developed by Newport News Shipbuilding and Dry Dock Company, under contract with the Maritime Administration.

### B. Pipe Shop Equipment Suppliers

1. Racking Systems, Semi-Automatic  
Ishikawajima-Harima Heavy Industries Company, Ltd. (IHI)  
Mitsui Engineering& Shipbuilding Company, Ltd.  
Oxytechnik  
Steffan Manufacturing Company  
Systems Equipment Company
2. Surface Preparation and Coating, Semi-Automatic  
Binks Manufacturing Company  
Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI)  
Mitsui Engineering& Shipbuilding Company, Ltd.  
Oxytechnik  
Vacu-Blast Corporation  
Wheelabrator-Frye, Inc.
3. Cutting and Measuring, Semi-Automatic  
Cypress Welding Manufacturing Company  
Do-All Company  
Fairfield Machine Company, Ltd.  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Mitsui Engineering& Shipbuilding Co., Ltd.  
Oxytechnik  
W. K. Stamets Company  
Steffan Manufacturing Corporation  
Vernon Tool Company  
Wallace Supplies Manufacturing Company
4. Marking Devices, Semi-Automatic  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Mitsui Engineering& Shipbuilding Co., Ltd.  
Oxytechnik  
W. K. Stamets Company  
Wallace Supplies Manufacturing Company
5. Conveyer Systems and Kickouts  
Do-AU Company

- Ishikawajima-Harima Heavy Industries Co., Ltd.  
Mitsui Engineering& Shipbuilding Co., Ltd.  
Oxytechnik  
Pandjiris Weldment Company  
W. K. Stamets Company  
Vernon Tool Company  
Wallace Supplies Manufacturing Company
6. Contour Cutting  
Cypress Welding Manufacturing Company  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Mitsui Engineering& Shipbuilding Co., Ltd.  
W. K. Stamets Company  
Steffan Manufacturing Company  
Vernon Tool Company
7. End Preparation  
Conrac Corporation  
Fairfield Machine Company, Inc.  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Mitsui Engineering& Shipbuilding Co., Ltd.  
W. K. Stamets Company  
Steffan Manufacturing Corporation  
Vernon Tool Company
8. Hole Burning Devices  
Cypress Welding Manufacturing Company  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Koikie Sanso Kogyo Co., Ltd.  
Steffan Manufacturing Corporation
9. Branch Welding  
Research and Development
10. Flange Welding and Finishing, Automatic  
ESAB-HEBE Company  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Mitsui Engineering& Shipbuilding Co., Ltd.  
Oxytechnik
11. Bending with/without Flanges, Automatic  
Comae Corporation  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Mitsui Engineering& Shipbuilding Co., Ltd.
12. X-ray, Semi-Automatic  
Research and Development

### SEMI-AUTOMATIC OR AUTOMATIC PIPE FABRICATION SYSTEMS SUPPLIERS

#### C. Hardware Systems Suppliers

Ishikawajima-Harima Heavy Industries Co., Ltd.  
MECAVAL International/USA  
Mitsui Engineering& Shipbuilding Co., Ltd.  
Oxytechnik

#### D. Software Package Suppliers

Hitachi Shipbuilding Co., Ltd.  
Ishikawajima-Harima Heavy Industries Co., Ltd.  
Kockums  
Mitsui Engineering & Shipbuilding Co., Ltd.  
Newport News Shipbuilding & Dry Dock Company (Under Development)

Hardware can be provided, and in some cases the software, to perform as an integrated system to produce the following functions:

- Automatic Pipe Storage
- Automatic Pipe Cutting
- Automatic Measuring
- Automatic Contour Cutting
- Automatic Fitting/Welding Straight Pipe Pieces
- Automatic Flange Fitting & Welding
- Automatic Flange Cleaning
- Automatic Bending with/without Flanges
- Automatic Transfer Device Kickouts
- Automatic External Surface Preparation and External Coating

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